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SOME BYGONE OPERATIONS IN SURGERY.

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II. CUTTING FOR THE STONE *(continued)*.

FRÈRE JACQUES' OPERATION.

CUTTING on the gripe and the Marian operation held their own throughout Europe until Frère Jacques, seemingly by accident, stumbled upon a better method, which—improved by Rau in Holland and by Cheselden in England—became lateral lithotomy as it was known and practised by the last generation of surgeons throughout the civilized world.

Frère Jacques, born in 1651, as Jacques Baulot, of poor parents in Franche-Comtè, served as a trooper in a French cavalry regiment from 1657 to 1672. Released from service he acted as servant to Pauloni, a strolling Italian lithotomist and curer of ruptures, with whom he wandered for six or seven years through France and Italy. He adopted a semi-religious habit and began to call himself Frère Jacques in 1688, but it is doubtful whether he ever took any vows, though he may perhaps have become a lay-brother of the Order of Saint Francis. He did not assume a full religious habit, and is always represented as wearing an enormous hat, a relic perhaps of his strolling years.

In 1695 he made friends at Besançon, and two years later he was in Paris with a commendatory letter which led the surgeons at the Hôtel-Dieu to put his skill to the test by ordering him to extract a stone from a dead body. Jean Méry, a skilled anatomist, Surgeon to the Hôtel-Dieu, watched the operation, and afterwards made a careful dissection of the parts. He reported that the incision had passed between the erector penis and the accelerator urinæ without wounding either muscle; that the whole thickness of the prostate had been divided in the deeper part of the wound in a postero-lateral direction, and that the neck of the bladder as well as a portion of the wall beyond the prostate had been cleanly divided. Méry appreciated the value of the operation, for he pointed out that no important blood-vessel was involved, that greater space was given for the extraction of the stone, and that the tearing and bruising unavoidable in the Marian method was almost entirely avoided.

The results obtained by Frère Jacques at this time proved to be unsatisfactory. He cut 60 patients and 25 died, whilst the Paris surgeons, using the older method to which they were accustomed, only lost 3 out of 22. Frère Jacques was therefore discredited and returned for a year to his wandering life, in the course of which he visited Holland, where in 1699 he was so successful that J. J. Rau (b. 1668), a former pupil of Méry in Paris, who had been appointed the operating surgeon at the Amsterdam General Hospital, copied his methods with much success. In 1700 Jacques was recalled to Versailles, and G. C. Fagon (b. 1638), surgeon to Louis XIV, had him properly instructed in the anatomy of the parts on which he operated. Frère Jacques profited by the instruction, modified his operation, and practised with such success in Holland that the magistrates at Amsterdam presented him in 1704 with his portrait and a set of gold sounds. The portrait was painted by Poel and was engraved by Schenk.

Frère Jacques died in his native village on Dec. 7, 1719. He appears to have been a good Catholic and abounding in charity. He frequently operated upon the poor without fee, and is said to have melted down the gold sounds and distributed the proceeds amongst them. His name is connected with two distinct operations. The first one, learnt perhaps from his master the itinerant lithotomist, resembled that recommended by Pierre Franco in 1556 which had never come into general use; the second operation he evolved after Fagon had taught him some anatomy.

In the first operation a staff without a groove was introduced into the bladder, and an incision with a long dagger-shaped knife was made by the side of the left ischium. The incision was carried obliquely upwards, and divided everything between the tuber ischii and the staff until the wound was large enough to admit a finger into the bladder. An instrument which he called his 'conductor' was then passed along his finger, and along the conductor he passed a pair of forceps. Having introduced the forceps he withdrew the conductor, and as soon as the stone was found he withdrew the staff and then removed the stone by means of the forceps.

In the second method the round staff was replaced by one with a groove, and an ordinary scalpel was used instead of the long dagger-shaped knife. The position of the skin incision was the same as before, but the deeper incision was quite different; instead of passing the knife through the cellular tissues surrounding the bladder and cutting its posterior wall, the neck of the bladder and the prostate were divided by passing the knife along the groove in the staff. The rectum and the pudic artery were thus less likely to be injured. The operation proved so satisfactory that Frère Jacques cut 38 patients in succession at Versailles without a single death.

Rau watched Jacques operate, learnt the secret of the second improved method, practised it with success, but, to his lasting shame, allowed his colleagues and pupils to believe that he still divided the posterior wall of the bladder. Wounds of the rectum, extensive extravasation, and sloughing of the soft cellular tissues therefore continued to be the rule until Cheselden elaborated a still more satisfactory operation.

FER. JACOBUS de BEAULIEU Archiepiscopus Burgundiæ, Lithotomiæ omnium Europæarum peritissimus.

THE PATHOLOGY OF CONGENITAL TORTICOLLIS.

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An explanation of the sequence of events leading up to congenital torticollis which carries with it even the least conviction has for many years been lacking in text-books of surgery. The present paper is based upon a clinical and pathological survey of 90 cases of torticollis and sternomastoid tumour which have come under my personal observation during the last few years. In addition, experimental work bearing upon the subject has been carried out in the Surgical Research Laboratory of the University of Edinburgh by permission of Professor D. P. D. Wilkie.

Any attempt to clarify the question of torticollis must deal with the following points: (I) The previous theories which have been advanced to explain the facts, and a short discussion of the weak points of such theories. (II) The relationship, if any, between congenital torticollis and the so-called 'sternomastoid tumour' of infancy: the morbid anatomy of the muscle in sternomastoid tumour and torticollis. (III) The etiology of the sternomastoid tumour: experimental reproduction of similar changes in muscle in animals. (IV) The etiology of various changes in the skeleton associated with the presence of torticollis.

I. THE OLDER THEORIES OF THE ETIOLOGY OF STERNOMASTOID TUMOUR AND TORTICOLLIS.

1. **The Hereditary Theory.**—This theory, supported by the observations of Jeannel, Pfeiffer, Fisher, and Joachimstal,[4, 6] cannot be maintained. Cases of torticollis occurring in parent and offspring are so infrequent as to render it certain that they are merely the result of coincidence.

2. **The 'Congenital' Theory.**—The view that the contracture, like club-foot or hare-lip, is due to some abnormality in the development of the fœtus, or to some abnormal pressure on the fœtus by the walls of the uterus, might be held to account for those rare cases where an infant is born with a fully developed torticollis. In the vast majority of cases, however, the wry-neck does not appear till months or years after birth. Also it would be difficult to explain by this theory why the contracture should be completely limited to the sternomastoid muscle in all cases except old-standing adult ones where secondary adaptive changes in surrounding muscles and fasciæ take place. Finally, a congenital theory cannot account for the fibrosis present in the contracted muscle.

3. **The Theory of Birth Injury.**—Stromeyer, who formulated this theory, holds that the sternomastoid muscle is ruptured during labour, giving rise

to the 'sternomastoid tumour', which is in reality a hæmatoma, and that the contracture following the organization of this hæmatoma is responsible for the wry-neck. This is the theory which commonly receives support to-day.

As we shall show later, this theory contains a grain of truth in that it realizes that there is an intimate relationship between the presence of a sternomastoid tumour and the subsequent development of a wry-neck, and also that both these conditions have some connection with long and difficult labours. On the other hand, the theory errs in attributing the sternomastoid tumour to the presence of a hæmatoma following rupture of the muscle during labour. At no time does the swelling show any of the characteristics of a hæmatoma, being from its inception firm, hard, and cartilaginous to touch, and never fluctuating or showing any sign of bruising. It does not appear immediately after birth. It affects in most cases the greater part of the muscle instead of a localized portion of it, and on microscopical examination it shows no appearance which can in any way suggest a hæmatoma. Finally, true hæmatomata produced experimentally by tearing a muscle leave no trace of contracture behind them and in no way resemble sternomastoid tumours (Witzel).[13]

4. The Theory of Infective Myositis following upon Contusion of the Sternomastoid Muscle at Birth. — This was based upon the microscopical appearances of the excised muscle. It has been shown by Kempf,[7] however, that there is no foundation for the belief that there is any infection present. He comes to the conclusion that the microscopical appearances seen are those of the repair of a hæmorrhagic infarct, a statement which is, as we shall see later, entirely true.

5. The Nervous Theory.—Few authorities support this theory. Golding Bird incriminated a cerebral lesion in intra-uterine life, while Gallavardin and Savy[3] observed atrophy of the anterior-horn cells in the cervical cord in an adult case of torticollis. It is probable that these changes are secondary to the destruction of muscle, and are analogous to the atrophy of anterior-horn cells which follows upon the amputation of a limb.

6. The Ischæmic Theory.—First suggested by Mickulicz, this view was supported when Nové-Josserand and Viannay[10] undertook a detailed investigation of the circulatory system of the sternomastoid muscle, and showed the possibility of interference with the blood-supply of the muscle taking place during labour.

This theory marks the most modern and most accurate work on the subject, and, as we hope to show, it comes very close to the truth. It recognizes that the muscular fibrosis seen in torticollis is essentially a similar process to that seen in Volkmann's ischæmic contracture of the flexor muscles of the forearm. It errs in adopting too whole-heartedly the belief which was then (1906) widely accepted, that Volkmann's contracture results from arterial deprivation to the flexor muscles, a belief which has always been and remains to-day completely unsupported by any sound evidence, clinical, pathological, or experimental. As we shall see later, such fibrosis in muscle can only result from venous obstruction, producing, in fact, the true 'hæmorrhagic infarct' described by Kempf.

II. RELATIONSHIP BETWEEN THE STERNOMASTOID TUMOUR AND TORTICOLLIS: MORBID ANATOMY.

It is commonly stated in text-books that though torticollis, when it appears early in life, may follow directly upon the absorption of a sternomastoid tumour, yet the majority of cases appearing later in childhood have not been in any way connected with such a condition. Both types of torticollis present the same clinical and pathological appearances, and it would therefore appear rational to expect that all cases are attributable to a common cause.

Let us consider the main facts with regard to sternomastoid tumour and torticollis.

The Sternomastoid Tumour of Infancy. — The tumour appears usually from one to two weeks after birth, the commonest time being about ten days. It is, so far as my observations go, never present at birth. It is first noticed as a spindle-shaped swelling occupying the position of one sternomastoid muscle. Occasionally it affects only the sternal head of the muscle, but very frequently both sternal and clavicular heads are thickened. The small uppermost portion of the muscle close to the mastoid attachment is, however, seldom if ever affected. The enlarged muscle is hard to the touch, and gives a typical 'cartilaginous' sensation to the examining fingers which I have never felt elsewhere apart from the experimentally produced tumour which will be described later.

FIG. 110.—I. H., male, age 6 weeks. Large sternomastoid tumour. Excised in part and sectioned to show fibrous-tissue replacement of muscle.

If a child suffering from such a tumour is kept under observation, it is found that the tumour remains more or less stationary for from two to three months, and then is gradually absorbed, disappearing in from four to six months after birth.

It is not uncommon for such a child to exhibit a mild degree of torticollis while the tumour is at its height, but this is transient and is of the nature of an acute torticollis. As the tumour is tender to touch, the child holds the head to one side in order to relax the affected muscle as far as possible. On the other hand, in some cases with a well-marked tumour, a true torticollis commences at about four months of age when the tumour is diminishing in size, the head being apparently drawn over to one side coincidently with the absorption of the tumour.

Morbid Anatomy.—If the sternomastoid tumour is excised and examined, it appears to the naked eye to be composed entirely of glistening fibrous tissue, and presents an appearance not unlike a soft fibroma on section (*Fig.* 110). On microscopical examination (*Fig.* 111) it is found to consist of young and cellular fibrous tissue containing here and there the remnants of the original muscle fibres. Many of these fibres show an absence of nuclei, vacuolation, and are undergoing degeneration.

FIG. 111.—L. M., female, age 4½ months. Large sternomastoid tumour, with severe torticollis developing as resolution took place. The microscopical section is from the sternal head, and is stained by Azan's method. Cellular fibrous tissue and remains of muscle fibres are seen.

FIG. 112.—A. M., male, age 8 years. Torticollis. Deformity first noticed at 2 years of age. Parent could not recollect a tumour. Microscopical section from sternal head shows adult fibrous tissue with atrophic but viable muscle fibres.

Torticollis.—

Morbid Anatomy.—If the contracted sternal or clavicular head from a case of fully developed torticollis in a child of, say, 8 years of age is excised and examined (*Fig.* 112), the microscopical picture can only be interpreted as representing the terminal stage of a sternomastoid tumour. No degenerating muscle or young fibrous tissue is observed, but instead swathes of adult non-cellular fibrous tissue are seen, with, scattered amongst it, collections of muscle fibres which, though smaller than normal and varying somewhat in size and outline, are living healthy fibres and bear none of the stigmata of degeneration.

The microscopical appearances in themselves form convincing evidence that torticollis represents the end-result of a sternomastoid tumour; and, on investigating 36 cases of torticollis, it was found that 25 gave a definite history of a sternomastoid tumour shortly after birth which underwent absorption and was followed at varying periods up to some five or six years later by the development of torticollis. The cases in which no history of a tumour was obtained were mainly in older children, and are in all probability accounted for by changes in guardianship or the failure of a parent's memory to recall a trifling ailment of a passing character affecting one child of a family some six or ten years before. It is, in fact, an occasional experience in the out-patient department to discover a sternomastoid tumour which has remained unnoticed in a stout baby.

Reason for Late Development.—One point remains to be dealt with at this stage. How is it, if torticollis results from the fibrosis consequent upon the absorption of the sternomastoid tumour, that the wry-neck may not be noticed for years afterwards, in the majority of cases appearing about the age of 4? A little thought will make this clear. The neck of an infant is short, and it is not until about the age of 4 that the individual commences to grow from the proportions of a 'child' into those of the 'small boy or girl'. The whole bodily type of a child changes at this period. Prominent among the changes which occur is an increased growth in height, and this is especially marked in the relative increase in length of the neck, which assumes almost adult proportions. Suppose a child at this age to have suffered during infancy from a sternomastoid tumour which has become absorbed and left behind it a degree of residual fibrosis which was not sufficient to cause the immediate development of a torticollis. Such a muscle is crippled as regards the function of growth in comparison to its normal neighbour on the opposite side. The muscle substance on the affected side is partly replaced by an abnormal tissue which will not elongate with growth to the same extent as the normal muscle. When the growth period arrives, therefore, the fibrosed muscle lags behind in its elongation and becomes relatively shortened, producing the classical deformity.

III. ETIOLOGY OF THE STERNOMASTOID TUMOUR: EXPERIMENTAL INVESTIGATIONS.

We have already seen that the often-quoted theory that the tumour is a hæmatoma following upon rupture of the sternomastoid muscle during labour is erroneous, and that the ischæmic theory of Nové-Josserand and

Viannay errs in attributing the condition to arterial deprivation. Kempf's statement that the microscopical appearances are those of an organizing hæmorrhagic infarct comes very close to the truth.

Brooks,[1] of Chicago, has in recent years performed an interesting series of experiments upon isolated muscles in animals, and has established the following facts :—

1. Ligature of the artery supplying a muscle can produce atrophy of the muscle, but such atrophy is not accompanied by a massive formation of fibrous tissue. This fact is borne out by clinical observation. Ligature of the femoral artery, for instance, if it does not determine complete gangrene of the limb, causes marked muscular atrophy, but this atrophy is never accompanied by fibrosis and contracture in the affected muscles.

2. Ligature of the artery and vein together produces results which are essentially similar to those following ligature of the artery alone.

3. Ligature of the vein draining blood from the muscle alone, leaving the arterial supply untouched, results in a remarkable series of changes culminating in death of muscle fibres and a massive fibrous-tissue replacement of the whole muscle.

I have repeated these experiments, using some thirty dogs, and have found the observations of Brooks to be entirely accurate. I propose now to enter into a rather more detailed description of the changes following the operation of venous ligation in the isolated muscle of the dog.

Experimental Technique. — In all cases the sartorius muscle of the dog was used, as it is easy of access, and possesses a single vasculo-nervous bundle entering it at its proximal extremity. Under ether anæsthesia, and with surgical aseptic precautions, the muscle is exposed by a long incision down the front of the thigh. The muscle is separated from its sheath from origin to insertion save for the point at the medial aspect close to the proximal attachment where the vasculo-nervous bundle enters. This bundle is carefully dissected in order to expose its component parts. The nerve-supply to the muscle and the artery are carefully preserved, while the two venæ comites returning the blood are divided between ligatures. The operation is completed by tying a ligature around the two attachments of the muscle in order to interrupt anastomotic channels which may be present, especially at the proximal end. Immediately after this operation the muscle can be seen to become cyanotic in colour and the veins in the muscle become turgid. The fascial sheath and the skin incision are then closed with interrupted sutures.

Changes in Muscle following Venous Ligation. — Little change can be made out on palpation of the muscle for a week or ten days after operation, but after this period the muscle is felt to be hard and cartilaginous to touch. It conveys to the examining fingers a sensation which is exactly similar to that of the sternomastoid tumour in the child, and it will be noticed that this stage appears at approximately the same interval after operation in the dog as the tumour does after birth in the child.

A series of dogs subjected to this operation of venous ligation were killed at intervals up to six weeks afterwards and the muscles excised and examined. The accompanying illustrations (*Figs.* 113–116) show the naked-eye and microscopical appearances of the muscles.

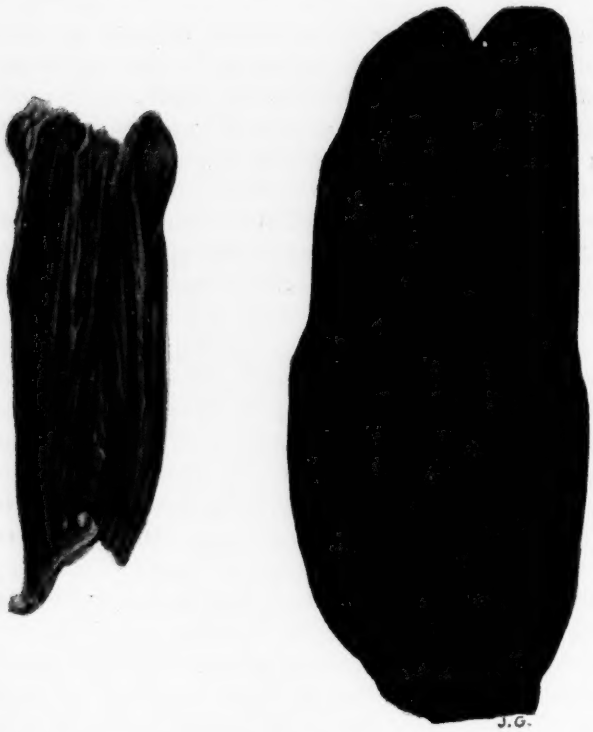

FIG. 113.—Dog No. 13. Sartorius muscle two days after venous ligation as compared with the normal muscle from the opposite limb (left). Intense œdema and cyanosis.

FIG. 114.—Dog No. 13. Two days after venous ligation. Microscopical section, stained hæmatoxylin and eosin, showing initial muscular degeneration and early invasion of the œdematous spaces by leucocytes.

Two days after operation the muscle presents a striking appearance. It is greatly enlarged, soft to touch, and dark blue, almost black, and necrotic in appearance as compared with the normal muscle from the opposite limb (*Fig.* 113). On microscopical examination (*Fig.* 114) the muscle fibres are seen to be separated by lakes of œdematous fluid, in which large numbers of polymorphonuclear leucocytes can be seen. The fibres are undergoing degeneration. It is to be noted here that all the experimental wounds healed cleanly by first intention, and in no case was any sign of suppuration evident.

One week after operation the naked-eye appearances are much the same, but on microscopical examination the leucocytic invasion is seen to be rather more intense.

Two weeks after operation the muscle is seen by the naked eye to be undergoing commencing fibrosis.

Eight weeks after ligation the muscle is seen macroscopically to be converted into solid fibrous tissue (*Fig.* 115). If the appearance of this muscle is compared with that of a sternomastoid tumour removed from a child six weeks after birth (*see Fig.* 110), the resemblance of the two tissues is striking. Microscopically, at this stage, young cellular fibrous tissue is seen to have replaced the

FIG. 115.—Dog No. 1. Sartorius muscle eight weeks after venous ligation. Almost complete replacement by fibrous tissue. This represents the experimental reproduction of the 'sternomastoid tumour' (*Fig.* 110).

FIG. 116.—Dog No. 1. Microscopical section of sartorius muscle eight weeks after venous ligation, stained by Azan's method. Young cellular connective tissue and muscular remnants are to be seen. Compare with *Fig.* 111.

œdema of the earlier stages. The muscular tissue has largely disappeared, but amongst the fibrous tissue there can be seen remnants of more or less atrophic and irregular muscle fibres (*Fig.* 116). This section may be

compared with a corresponding microscopical section of a sternomastoid tumour (*see Fig.* 111), which shows a pathological appearance essentially similar.

Finally, if the figure illustrating the microscopical appearances of the fibrosed muscle from an 8-year-old child the subject of torticollis is glanced at (*see Fig.* 112), it will be clear that the muscle from torticollis represents the end-result of the sternomastoid tumour, adult non-cellular fibrous tissue being now in evidence.

These observations strongly support the view that sternomastoid tumour and consequently congenital torticollis result from an acute venous obstruction of the muscle taking place during birth.

It is of interest to notice that, as *Fig.* 117 shows, the fibroblasts responsible for laying down the fibrous tissue are derived from the proliferation of the endothelium lining the smaller blood-vessels in the muscle.

FIG. 117.—Microscopical section from experimentally produced tumour of two weeks' standing, to illustrate the endothelial reaction which results in the budding off of numerous fibroblasts from the smaller blood-vessels.

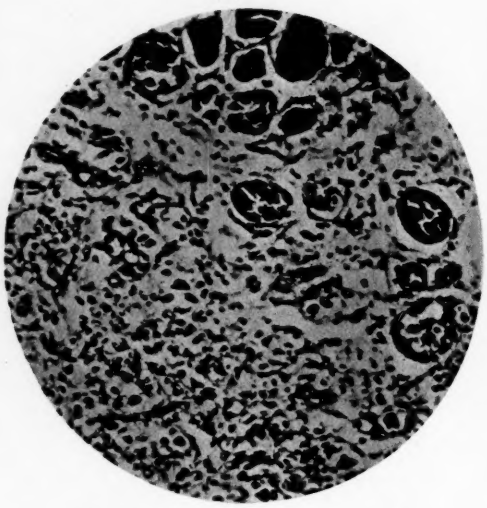

FIG. 118.—Microscopical section from experimentally produced tumour of ten days' standing. Stages in process of gradual disappearance of muscle fibres by autolysis can be seen.

It should be clearly realized that the death of the muscle, *per se*, is not the factor which determines the fibrous-tissue formation. It would appear that when a muscle fibre dies it undergoes autolysis, breaking up into a mass of granules which form as it were a 'shadow' of the original muscle fibre which gradually disappears (*Fig.* 118). Phagocytosis does not appear to be concerned in the removal of the products of autolysis. If the fibre dies of ischæmia consequent upon cutting off the arterial supply or the arterial supply and venous return together, so that no œdema results, no marked degree of fibrosis follows; but if acute venous obstruction is present along with a free arterial supply, the disappearing fibres, lying in œdematous spaces, are replaced by masses of fibrous tissue laid down in the œdematous fluid. In fact, the œdema appears to be the essential factor in causing the fibrosis.

Production of Venous Obstruction in Labour. — It is difficult at first sight to explain the mechanism by which such a venous obstruction can occur during labour, though a satisfying anatomical explanation is forthcoming in the counterpart of this condition, Volkmann's contracture of the flexor muscles of the forearm (Middleton [8, 9]). The sternomastoid muscle is derived from three different muscular segments. Muscle fibres derived from these segments flow into the neck and unite to form the three portions of the muscle, each portion retaining unaltered its own original arterial supply and consequently its own venous return.

The upper mastoid portion, which is very much shorter than one is generally led to believe, is situated at the mastoid extremity of the muscle, and is supplied by the superior sternomastoid artery derived from the occipital artery. This artery is short and runs a transverse course. The venous return from this portion of the muscle appears to travel through short trunks which penetrate the deep aspect of the muscle and join the large veins beneath. It is difficult to conceive of any mechanism by which these veins could become obstructed, and in fact a careful examination of sternomastoid tumours shows that this small mastoid portion of the muscle appears seldom, if ever, to be affected, and this portion is not the seat of fibrosis in torticollis.

The sternal head of the muscle receives its arterial supply through the middle sternomastoid artery, a branch of the superior thyroid artery. This branch takes origin from its parent trunk a short distance above the upper border of the omohyoid muscle, and the vascular bundle is seen and divided in every case of excision of glands in the neck as it runs backwards and downwards parallel to the upper border of the omohyoid muscle. On reaching the sternal head of the muscle, it does not at once enter it. It passes beneath this head, appearing in the interval between the sternal and clavicular heads. It then courses downwards along the posterior border of the sternal head, giving branches forwards to that head as it goes, but sending no branches to the clavicular head. The venous return from the sternal head appears to follow the artery of supply, and eventually terminates in the venous plexus formed by the junction of the superior thyroid and lingual veins with the common facial vein.

The clavicular head derives its arterial supply from the inferior sternomastoid artery, a small branch coming either direct from the thyreocervical trunk or from one of its branches, usually from the transverse scapular artery. The branch runs upwards upon the deep aspect of the muscle, supplying branches to it. The exact path of the venous return from this head is a little uncertain. Probably much of the blood is returned by a vein accompanying the artery of supply, but Mr. Saunders, of the Anatomical Department of the University of Edinburgh, has observed small venous trunks issuing from the surface of the muscle to join the external jugular vein.

Nové-Josserand and Viannay,[10] investigating the circulation of the sternomastoid muscle in the stillborn fœtus, found that these three systems of blood-supply were independent, each supplying its own portion of the muscle and failing to communicate with each other or surrounding arteries. If this is so, it follows, of course, that the venous systems are also independent.

Impressed with the theory of arterial deprivation, they proceeded to show that the arteries to the sternal and clavicular heads can be occluded in the fœtus if the head is placed in a position of extreme rotation such as occurs during labour, the tense sternomastoid muscle in this position being capable of compressing the vessels of supply where they pass beneath it. If, under experimental conditions, the middle and inferior sternomastoid arteries can be closed to injection by this means, it is not too much to suppose that the thin-walled veins may be shut off during labour without at the same time interrupting the arterial supply, thus reproducing, temporarily at all events, the condition obtaining in the experimental muscle after venous ligation. It is perhaps hardly necessary to emphasize the fact that such a conclusion must remain at present in the realm of pure theory, but it appears that some such hypothesis offers the only explanation of the origin of the sternomastoid tumour and congenital torticollis which is not seriously at variance with known clinical and experimental facts.

Another point remains to be cleared up in this connection. If sternomastoid tumour results from venous blockage in the positions of rotation assumed by the fœtal head during the passage of the pelvis minor, one would expect that such tumours would commonly occur following upon complicated labours, or normal labours which had been unduly prolonged, having therefore an unusually high incidence in primiparous cases. A survey of our series of cases gives us the following information: Out of 64 cases where the place occupied by the child in the family was known, 43 were the first children born to the mother. Of the remaining 21 who were not born of primiparæ, 16 were classified as either 'difficult prolonged labours', 'cross-births', or 'breech presentations'. Out of 83 cases in which the history of the labour was known, only 14 were described as normal, 46 were 'difficult' or 'prolonged', 15 were 'breech presentations', and 8 were 'cross-births'.

It is known that obstetrical paralysis of the Erb-Duchenne type almost invariably follows on a difficult delivery succeeding a prolonged and troublesome labour, being especially common after breech presentations. One would expect to find a high proportion of sternomastoid tumours associated with such cases. I therefore went through the histories of 54 cases of Erb's paralysis which had been under observation during the main period (from birth to three months) in which tumours might be found. The series is consecutive except that all cases which were not seen till they were over three months of age are excluded. Out of 54 such cases seen during the last five years, no fewer than 11—that is to say, about 1 case in 5—had exhibited a sternomastoid tumour.

Jepson[5] has shown that a venous blockage which has been complete for some hours is capable of setting up a process of fibrosis which continues even after the venous obstruction has been relieved. This might quite conceivably occur during labour, but nevertheless one feels that there must be some other factor at work which is capable of rendering such a temporary venous blockage permanent. It seems likely, judging from the appearance of the veins within a few minutes of experimental venous ligation, that thrombosis might well occur in the stagnant blood occupying the greatly engorged venous trunks in the muscle, and in point of fact such thrombosis can be observed

under the microscope in the earlier stages of the process (*Fig.* 119). If the whole venous tree of, for instance, the sternal head of the sternomastoid muscle were blocked for an hour or two during labour, thrombosis occurring in parts of the tree would obviously render the interference with the venous return from portions of the muscle permanent, with resulting fibrosis. This would explain the fact that the fibrosis of torticollis is classically patchy in character, with intervening areas of normal muscle. I have carefully examined many sections of muscle from sternomastoid tumours and cases of torticollis in an endeavour to find the remains of these thrombosed veins. One might expect that they would be difficult to find amongst masses of fibrous tissue months or years after the date of thrombosis, and, further, small nerve-trunks on section must be carefully distinguished from them. I have in fact been unable definitely to demonstrate such veins either to my own satisfaction or to that of Dr. James Davidson, Pathologist to the Royal Infirmary of Edinburgh, to whom I am indebted for much help on this point.

FIG. 119.—Microscopic section from experimentally produced tumour of one week's standing. Fibrosis is already advanced, and a thrombus is seen occupying a large vein.

IV. PATHOLOGICAL CHANGES IN THE SKELETON ASSOCIATED WITH CONGENITAL TORTICOLLIS.

Under this heading we must consider the exostosis which sometimes develops at the attachment of the clavicular head of the sternomastoid muscle, and the facial asymmetry and plagiocephaly which is invariably associated to a greater or less degree with torticollis.

1. **Clavicular Exostosis.**—In most cases of torticollis in which the fibrosis affects the clavicular head of the muscle to any extent the normal markings caused by the muscular attachment to the clavicle are increased, and occasionally a definite exostosis develops at this point. In the more marked cases the exostosis is visible in the X-ray film (*Figs.* 120, 121), and is easily palpable. Such an exostosis is never seen at the sternal attachment, where the fibrosed muscle fibres are separated from the bone by the normal tendon of insertion. It is only met with in the clavicular head, where the scar tissue comes into direct relationship to the bone. It would appear that the new bone formation is dependent upon the minute recurring traumata inflicted upon the subperiosteal layers of the bone through the shortened muscle.

2. **Changes in the Skeleton of the Face and Skull.** — If one examines a patient with congenital torticollis carefully (*Fig.* 122), one will notice in the

majority of cases a more or less well-marked asymmetry of the face and skull. The eyebrow on the side of the shortened muscle tends to slope downwards. The face below the level of the eyes appears to be shorter from above downwards and wider from side to side than on the normal side. In actual fact,

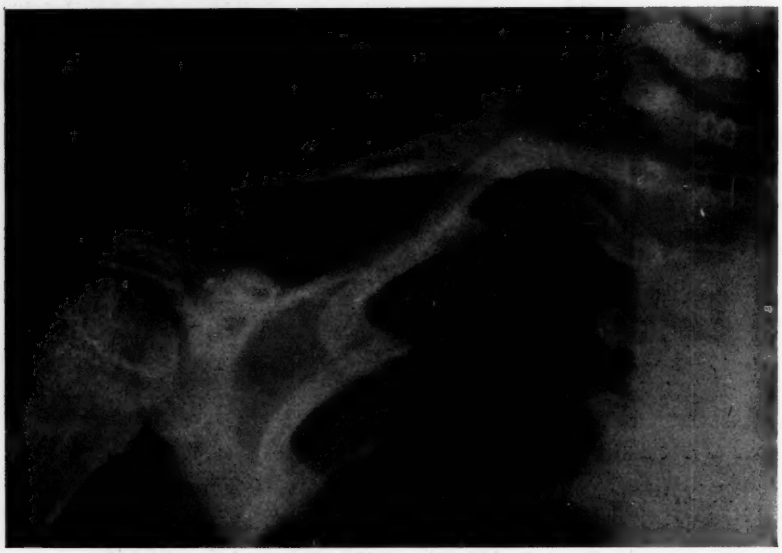

FIG. 120.—H. W., age 7. Torticollis with fibrosis affecting especially the clavicular head of the right sternomastoid. A well-marked exostosis is visible in the radiogram at the clavicular attachment of the muscle. At operation this was removed.

FIG. 121.—Male, age 25, with torticollis. Radiogram of specimen of lower end of sternomastoid removed at operation. A large exostosis is seen to occupy the fibrosed clavicular head. No ossification is present in the sternal head, though the fibrosis was equally intense in both portions of the muscle. (*Mr. J. M. Graham's case.*)

in a well-marked case, the measurement from the external angular process to the angle of the mandible will be found to be shorter on the one side than on the other (Staub[12]).

On turning to the skull one notices that on the affected side the frontal eminence is flattened, while there is a well-marked bulge in the occipital region on that side. Conversely, on the opposite side the frontal eminence is unduly prominent, and the occipital region is, if anything, rather flat. In other words, the vault of the skull has been thrown back on the affected side and forwards on the opposite side, giving rise to a deformity which is, in all essentials, comparable to that seen in the thorax in cases of dorsal scoliosis.

The membranous portions of the skull—that is to say, the bones of the vault of the skull and those of the face—depend for their support upon the cartilaginous base of the skull. Of this base, the essential 'key-stone' is formed by the basi-occiput and the basi-sphenoid. These represent developmentally a modification of the cephalic extremity of the vertebral column

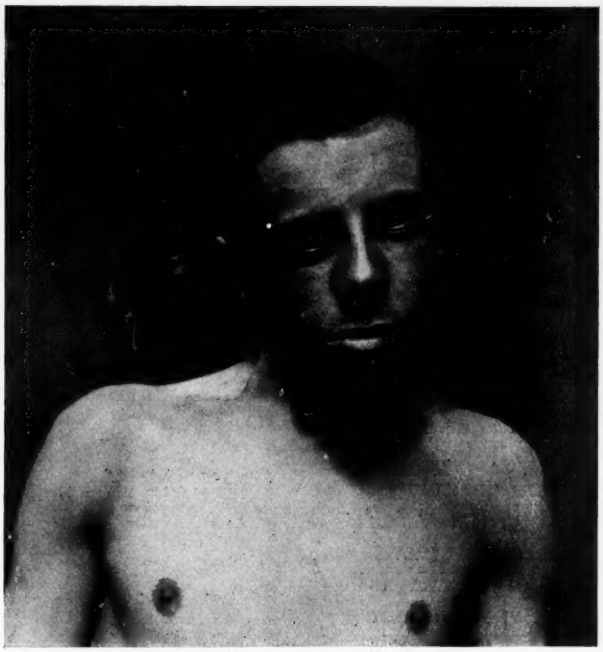

FIG. 122.—Youth, age 18, with torticollis. To illustrate well-marked facial asymmetry.

and form the oldest portion of the base of the skull. On this foundation the anterior and posterior portions of the base are formed by the development of cartilaginous expansions in which the floor of the anterior fossa and the posterior portion of the posterior fossa are laid down. It is clear, then, that any deviation from normal alinement on the part of the basi-occiput and basi-sphenoid will affect the growth of the skull and face as a whole. It is convenient to stress the vertebral origin of the basi-occiput and basi-sphenoid, as it would appear that any curve in the cervical portion of the vertebral column during the early growth period is continued into the base of the skull as a curve which may be associated with a twist corresponding to the well-known vertebral rotation which occurs in cases of scoliosis. The term 'scoliosis capitis', which has been applied to this deformity, appears therefore

to be a strictly accurate one, the deformity of the base being in every way comparable with an ordinary scoliosis, while the asymmetry of the skull and face corresponds to that of the thorax in a case of dorsal scoliosis associated with vertebral rotation. The deformity of the skull varies according to the severity of the cervical curve as long as growth continues, and one therefore finds that the facial asymmetry of torticollis tends to diminish gradually after cure of the torticollis by operation; and indeed, if treatment is undertaken early, all trace of asymmetry may disappear.

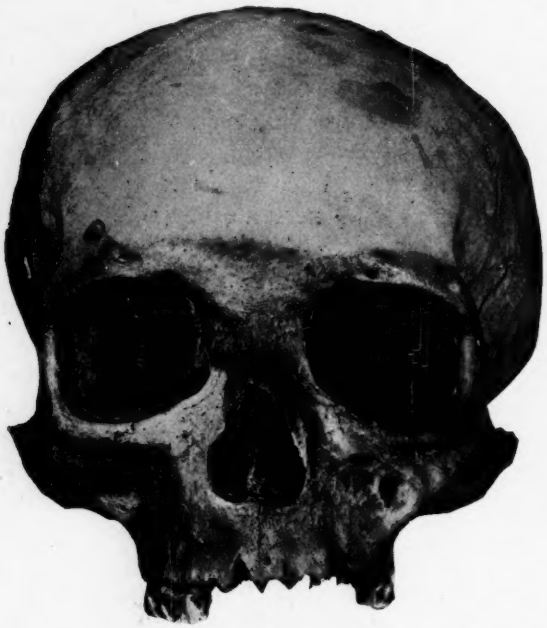

FIG. 123.—Professor Sydney Smith's specimen. Norma frontalis. Note the well-marked facial asymmetry.

It is convenient at this point to note that the problem of the so-called 'idiopathic facial asymmetry and plagiocephaly of the newborn' is easily solved when viewed in this light. Children are frequently born with plagiocephaly, more or less severe, which tends to decrease after birth, and in all but the worst cases disappears entirely in the course of a few years. This phenomenon has received many explanations, none of which is satisfactory. In the light of our present knowledge of scoliosis capitis, however, the etiology becomes clear. Such a child has developed in utero with the head in a laterally flexed position, and the skull has consequently grown in an asymmetrical manner. At birth the neck comes straight, and the asymmetry of the skull at once diminishes with further growth.

FIG. 124.—Professor Sydney Smith's specimen. Norma occipitalis. The facial bones have been blacked out in order to show up the hypertrophy of the left (affected) mastoid process, the difference in size between the occipital condyles on the two sides, and the definite rotational twist of the base of the skull.

I have been fortunate in having access to the skull of an adult who suffered from congenital torticollis, now in the Museum of

Forensic Medicine in the University of Edinburgh, which illustrates many of the changes in the skull. I am indebted to Professor Sydney Smith for permission to utilize this specimen. Three photographs are reproduced herewith, and show the angling of the base of the skull in the region of the basi-occiput and the asymmetry of the face very clearly (*Figs.* 123–125). *Fig.* 124 shows also that there is a very definite rotational deformity present, the base of the skull being twisted so that the under aspect tends to look towards the side of the affected sternomastoid muscle. In association with this twist there is a marked discrepancy in size between the two occipital condyles.

FIG. 125.—Professor Sydney Smith's specimen. Norma basalis. Note the well-marked angle between the anterior and posterior portions of the base of the skull, shown up especially in this view by the gross deviation of the external occipital crest.

It is of interest to note that the mastoid process on the affected side is heavy and well formed, while that on the opposite side is unduly small. This is to be expected when one remembers that the mastoid process owes its presence to the pull upon the skull of the sternomastoid muscles when these are developed on the assumption of the erect posture (Darwin[2] and Schaafhausen[11]). The mastoid processes are therefore not present in the pronograde vertebrate. The human infant has hardly any mastoid process at birth, and this structure commences to appear when the child learns to hold up his head in the erect position. It is clear, therefore, that in the case of torticollis the shortened muscle will exert a stronger pull upon the mastoid region than the normal one, and the process on the affected side will develop to a greater extent.

CONCLUSIONS.

1. In all cases 'congenital' torticollis results from fibrosis in the sternomastoid muscle consequent upon the development and absorption of the so-called 'sternomastoid tumour' of infancy.

2. Sternomastoid tumour, and therefore torticollis, result from a temporary acute venous obstruction in the muscle, this obstruction taking place during labour.

3. It is probable that such a temporary venous obstruction has been rendered permanent by patchy intravascular clotting in the obstructed venous tree.

4. Attention is drawn to the frequent occurrence of an exostosis at the clavicular attachment of the sternomastoid muscle in cases of fibrosis affecting that head.

5. The facial asymmetry and plagiocephaly associated with torticollis is shown to be dependent upon the prolongation of the cervical curve into the base of the skull, and is therefore properly called a scoliosis capitis.

6. A reasonable explanation is given of the etiology of idiopathic facial asymmetry and plagiocephaly of infants.

I am indebted to Miss Herzfeld and Mr. Norman Dott, of the Royal Edinburgh Hospital for Sick Children, for the generous fashion in which they have referred all cases of sternomastoid tumour and torticollis to me during the course of this investigation, and also to Mr. J. M. Graham for material from adult cases of torticollis.

The expenses of the experimental work were in part defrayed by a grant from the Moray Fund, and I wish to record my thanks to Mr. D. M. Greig, Curator of the Museum of the Royal College of Surgeons of Edinburgh, for much help with regard to illustrations.

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TWO CASES OF HÆMANGIOMA OF THE BLADDER.

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CASE HISTORIES.

Case 1.—A male patient, age 28, complained of symptomless hæmaturia of moderate severity which had recurred on several occasions during a period of three months.

On Examination.—The bladder was healthy in every respect save that around the left ureteric orifice were three nævoid patches. They were purplish in colour and consisted of small venous dilatations which projected but little into the bladder. Three groups were seen. The uppermost, about the size of a sixpence, lay above the ureteric orifice, and through the middle of it ran two normal-looking forked blood-vessels of redder colour, apparently arteries. Two smaller groups, each about the size of a pea, lay below the ureteric orifice. All these areas were cauterized with the high-frequency current and the symptoms disappeared. There was no pathological confirmation.

The position of these nævi was similar to that occupied by the submucous hæmatomata of a descending ureteric stone. Symptoms of such a condition had been absent, and the appearance of the lesions did not suggest a submucous hæmatoma, as they were purplish in colour and covered with healthy mucosa, whilst the individual vessels could be clearly identified. They were observed on two occasions several weeks apart and the appearance was identical at each examination, which would not have been the case had they represented a temporary lesion. After cauterization they almost entirely disappeared. This cystoscopic appearance was figured by me in my handbook on cystoscopy.[1]

Case 2.—A male, age 14, was admitted to the Pendlebury Children's Hospital suffering from hæmaturia, and was transferred to the urological service at the Royal Hospital in July, 1928. Hæmaturia had occurred at intervals of two to four months since birth, pain on micturition having developed recently.

Family History.—The patient came of a healthy family, and no urinary disorders were reported. There was no evidence of tuberculosis in the family.

Personal History.—He had suffered from diphtheria, scarlet fever, measles, and chicken-pox. He had a congenital dislocation of the right hip, with a false joint; over this an abscess developed and was incised at the Children's Hospital. Movements of the hip were good up to a right angle, and the hip could be slightly abducted; there was two inches of shortening.

On Examination.—The boy was badly nourished, anæmic, and thin. The tongue was slightly coated and the teeth were carious; heart and lungs were normal. Examination of the abdomen showed no abnormality, and the kidneys could not be palpated. There was a severe degree of what appeared to be internal hæmorrhoids. In the left scrotum a venous mass was palpated which felt like an ordinary varicocele. The left testicle was soft and atrophic. The right testicle was about the size of a pea, but was in the normal position; it had apparently no testicular sensibility. In the epididymis a cyst the size of a bean was felt. On the dorsum and lateral aspects of the glans penis the submucous vessels were diffusely dilated, suggesting a cavernous angioma. On the dorsum of the penis itself was a firm plaque of slightly purplish colour the size of a small almond which occupied the subcutaneous tissue. On the outer side of the right thigh were two large irregular

areas, each about three to four inches in diameter, lying deeply underneath the skin. They were diagnosed as cavernous angiomata. They were soft, and collapsed on pressure, leaving hollows in the site they had previously occupied. A bandage was worn over them, as they ached when the patient occupied the upright position for long. A scar over the posterior aspect of the right hip indicated the site of incision of the above-mentioned abscess.

Urine.—The urine contained albumin in fair quantity, and pus, together with occasional blood. Its reaction was acid, and the specific gravity varied between 1010 and 1020. Microscopical examination showed numerous pus-cells and a fairly large number of red blood-corpuscles. No casts and no tubercle bacilli could be found; cultural methods revealed a growth of the *Staphylococcus aureus*.

FIG. 126.—Appearance of hæmangioma of the bladder after removal.

Radiography.—A skiagram of the urinary tract showed several shadows on the right side at the level of the second and third lumbar vertebræ which were regarded as being outside the urinary tract. The radiographical examination was otherwise negative.

The Blood Urea was 40 mgrm. per 100 c.c. of blood.

The urea concentration on July 7 was:—

Before administration of urea	1·75 per cent
1st specimen	1·75 „ „
2nd specimen	3·1 „ „
3rd specimen	3·4 „ „

The temperature and pulse were normal.

Cystoscopy.—On cystoscopy the bladder held about 6 oz. and the ureteric orifices were similar and normal. A large tumour was observed immediately behind the air-bubble, occupying the middle line and extending down towards the 'bas fond'. It was for the most part reddish in colour, and had numerous obviously vascular areas on its surface, between which were patches of sandy yellow colour which projected into the bladder cavity and had a convex intravesical surface. Projecting from it were a large number of tags of œdematous mucosa not unlike the villi of a papilloma. No central blood-vessel was observed in these, but a few of them appeared to have extravasated blood in their interior. Many of them were club-shaped and stunted. No cystoscopic drawing was obtained, but the characters of the tumour can be judged from the drawing of the fresh specimen (*Fig.* 126).

Operation (July 6).—The bladder was filled with 6 oz. of solution, and a mid-line suprapubic incision extending from the pubis to the umbilicus was employed. On exposure of the bladder a tumour half the size of a tennis ball was discovered on its upper and posterior surface, partly covered by peritoneum and partly in front of the peritoneal reflection. The tumour formed a projection half an inch in depth beyond the external surface of the bladder. The urachus was thickened and entered its posterior part about the mid-point. It was cut close to the bladder.

Fig. 127.—Microscopical appearance of hæmangioma of the bladder.

The bladder was mobilized on its lateral aspects, and the peritoneum was then opened. Investigation of the intraperitoneal structures showed a nævoid condition of the transverse colon from its middle point onwards to the descending colon and to the rectum. A similar condition was felt in the retroperitoneal structures internal to the colon. The nævoid tissue in the rectum was evidently continuous with the hæmorrhoidal tissue previously remarked. The bladder, having been freely mobilized, was opened, and the tumour was found to project into the cavity for one to one and a half inches. Its margins were moderately well defined, there being no evident cavernous tissue beyond them. It was excised together with a margin of healthy bladder wall. Bleeding was not unduly troublesome nor was hæmostasis difficult. The bladder was re-formed, an in-lying catheter inserted, and the wound was closed in layers, a tube being left in the suprapubic space.

Progress.—Convalescence was uneventful except for slight infection of the abdominal wound round the area previously occupied by the suprapubic tube. The patient was discharged on Aug. 6, 1928, the wound being healed. The bladder capacity was approximately 4 oz. and the urine clear.

Since then there has been no hæmaturia. Micturition occurs at the normal intervals, and the patient is comfortable and well. Fresh cystoscopy has been refused. There is a tendency for the angiomatous tissue on the glans penis to become more pronounced.

The accompanying coloured drawing (*Fig.* 126) shows the specimen after removal. The irregularity of the surface is evident, and numerous vascular protrusions are well shown. The surface was seen at cystoscopy to be covered with villiform processes, and these can be detected in the drawing. In actual fact they fell flat when the specimen was displayed for the artist, and had to be floated up in fluid in order to allow her to identify them. They were more numerous than would appear from the drawing. The fact that the tumour is sharply circumscribed is also evident.

I am indebted to Professor Shaw Dunn for cutting sections and making the following report :—

Tumour of the Bladder Wall.—" Histological examination of a large block taken to include the margin of the growth shows that it is composed of large cavernous vascular channels. These contain blood and are lined by a single layer of endothelium : their walls are composed of rather hyaline fibrous tissue and show no intrinsic muscle. Muscle bands of the bladder wall pass among the vascular channels in all directions, showing that the tumour is closely incorporated with this tissue. The structure is typical of a cavernous hæmangioma." (*Fig.* 127.)

REVIEW OF THE LITERATURE.

The rarity of this condition is attested by all writers. I have collected from the literature 19 cases, of which the first (Broca) is of very doubtful authenticity.

Broca[2] is generally referred to as having discovered the first angioma, but his case is of doubtful authenticity, and is regarded as a papilloma by Pousson. The tumour was the size of a hazel nut, and consisted of a network of dilated capillaries. It was discovered at autopsy on an old woman.

Langhans[3] observed a cavernous tumour in the bladder of a 19-year-old youth who had periodically suffered from hæmaturia since the age of 10. This specimen also was discovered at autopsy, the latest bleeding having been so severe as to end fatally, and having apparently been excited by alcoholic excess. Several cavernous tumours, of which the largest lay above the left ureteric orifice, were found. At other parts of the bladder the subserous veins were dilated and tortuous. More than one of these showed rupture, with plugging of the orifice by a clot. Accurate histological description was rendered difficult owing to faulty preservation of the specimen.

Albarran[4] reported a case of a 64-year-old man who suffered from profuse symptomless bleeding and died at operation. At the post-mortem a retrotrigonal tumour the size of a pea was found in an otherwise healthy bladder. Microscopically it proved to be a cavernous angioma, in which sinuous capillaries with ampullary dilatations were separated from each other by thin connective-tissue septa.

Arbuthnot Lane[5] reported a child 3½ years of age who for two years had suffered from hæmaturia of varying severity. The skin over the gluteal regions showed several small cutaneous nævi. Suprapubic cystotomy revealed vascular masses which protruded into the wound. Almost the whole of the viscus was affected. On account of this widespread involvement no treatment was undertaken, the bladder being closed. Cessation of the bleeding and improvement in health followed the operation.

Berliner[6] reports an 11-year-old schoolgirl who suffered from her fourth year onwards with intermittent hæmaturia which had recently increased considerably in intensity and caused a severe degree of anæmia. Pain and difficulty in micturition had made their appearance latterly. Cystoscopy showed numerous large circumscribed purple swellings and rounded elevations, some of them the size of one's little finger. Only small areas at the apex of the bladder were unaffected. Operation—cystotomy and cauterization—was performed, with cessation of the bleeding to date of publication. Other lesions: (1) On the right labium majus a telangiectatic angioma the size of a walnut (cauterized); (2) The face was strikingly asymmetrical, the left side appearing to be swollen owing to hypertrophy of the parotid and lower jaw. Six months after the operation investigation showed that a stone had formed on a silk suture and necessitated crushing.

Bryan[7] reported a man, age 35, who complained of hæmaturia. Cystoscopically a broad sessile tumour was seen to be present at the back part of the bladder. It was as big as a thumb-nail and projected into the bladder. It was removed through a suprapubic incision by blunt dissection and the base was cauterized. Microscopically a cavernous angioma was discovered and is illustrated.

Thumim[8] reports the history of a 45-year-old woman who for years had experienced pain on micturition. Cystoscopy showed a small tumour, situated 2 cm. behind the ligamentum interuretericum, which consisted of three parts, two of which exhibited an intense blue coloration. The symptoms abated and no operation was undertaken.

Bachrach[9] discovered cystoscopically what was apparently a cavernous angioma in the bladder of a 13-year-old girl. The patient had had vaginal hæmorrhage at the age of 4 and again at the age of 9. For the last one and a half years there had been irregular bleeding from the vagina which had been regarded as menstrual, but which on one occasion had been unduly severe. Hæmaturia showed itself when the girl was 13 years old, together with pain in the thigh and frequency of micturition. In the upper left quadrant of the bladder a tumour the size of a cherry-stone was seen through the cystoscope to project into the bladder cavity. It was in part transparent and in part opaque (? thrombosis). It was vascular in character. Treatment: general. No operative or pathological confirmation was obtained. On the outer side of the thigh extensive nævi were observed, and these are illustrated. They extended from the trochanter to below the knee. Presumably the uterine hæmorrhage arose from nævoid lesions in the womb.

Blum,[10] in the series of cases which he reported in his monograph on bladder diverticula, describes that of a man, age 64, who for four years had suffered from hæmaturia of variable intensity which was becoming progressively worse. Recently he had developed a severe anæmia. At operation the diverticulum was excised, and an angioma the size of a lentil was found projecting from the anterior wall. This had been invisible at cystoscopy owing to its position within the diverticulum. Blum remarks that this could only have been discovered cystoscopically had the cystoscope been introduced within the diverticulum.

Launay, Achard, and Carrière[11] report an angioma discovered accidentally

during an operation for salpingitis and appendicitis. On opening the peritoneum a firm lobulated tumour the size of an orange was observed embedded in the musculature of the bladder. Operation: partial cystectomy, salpingectomy, appendicectomy. The vesical surface of the tumour was smooth, and covered with healthy mucosa. A section running from the vesical to the peritoneal surface showed the latter area to be formed of fibrous tissue, and from it septa diverged towards the mucous surface, dividing the tumour into lacunæ of various sizes, of which the least was about 5 mm. in diameter. Some of these were filled with blood-clot, others with a gelatinous substance of greenish colour. All the cavities were lined with a single layer of flattened endothelium. (Illustrated.)

Rafin[12] reports the cystoscopic appearances in the bladder of a girl of 17 who suffered from severe intermittent hæmaturia. The trigone and ureteric orifices were normal. Part of the remainder of the bladder was covered with red granular elevations separated from each other by small intervals of pale colour. At other portions of the bladder "large bluish vessels forming veritable venous sinuses" were observed. Some appeared to be on the point of ulcerating. He regards it as a "diffuse venous nævus". There was no operation and no pathological confirmation.

Sotti[13] describes in great detail a specimen removed post mortem from the body of a woman, age 36, who died of bronchopneumonia. There was no record of any bladder complaint. The angioma was at first sight judged to be a papilloma. It was about 13 mm. in diameter, and occupied the base of the bladder, abutting on the neck, and encroaching for a short distance posteriorly on the urethra. Its surface was rounded, and covered with smooth, glistening, healthy mucosa the vessels of which were normal in type and did not resemble those of the growth. The tumour was closely incorporated with the vesical musculature. Its microscopic appearances are recorded at great length, and are those of a cavernous angioma with considerable development of elastic tissue.

Hübner[14] describes a female patient 11 years of age who had suffered from the age of 6 with hæmaturia. She was pale, thin, and anæmic. Cystoscopic investigation showed a cavernous angioma lying behind the air-bubble, consisting of tensely filled venous dilatations some of which were isolated whilst others were confluent, and the venous dilatations appeared like a row of pearls. The tumour extended down within 3 cm. of the right ureteric orifice. Treatment consisted of partial cystectomy; that part of the growth which lay close to the right ureteric orifice was not removed. There was strikingly little bleeding from the bladder incision. The pathological examination showed a cavernous angioma with much elastic tissue in the septa. Some weeks later this patient developed a fresh hæmaturia, and it was found that those portions which could not be removed had developed fresh angiomatous tissue. They were treated by thermo-coagulation, and after three sessions the bleeding ceased.

Faerber[15] has reported what appears to be the same case as the above.

Kidd and Turnbull[16] report a case which they call an angiomyoma, the patient being a male, age 29 years. A smooth pedunculated tumour the size of a date and looking like a raspberry was attached to the anterior margin

of the internal meatus by a narrow stalk. Its apex was ulcerated. Histologically the tumour showed itself as " an excrescence of muscularis, mucosa, and epithelium supplied with abnormally large and numerous vessels " . . . " the muscle bundles are not connected with the formation of the vessels as is the case in some angiomata ; the vessels are perfectly formed, and are absolutely distinct structures ". This tumour does not appear to be quite comparable with the ones we have described.

Scholl,[17] in an article on histology and mortality in cases of tumour of the bladder, has reported three cases under the heading of angioma, two of which do not appear to be relevant to the present paper, the first being an " inoperable sessile growth covered with papillomatous excrescences ", and the second a " highly vascular myxoma ". A third patient was a girl of 7 who had had persistent slight hæmaturia for six years. Recently a small amount of blood had been passed from the rectum. Cystoscopy revealed an ulcerating bleeding tumour in the base of the bladder. Soon after, and before operation could be performed, the patient had a severe hæmorrhage from the *rectum* and died. Necropsy revealed an extensive cavernous angioma growing from the base of the bladder and invading the rectal mucosa. No microscopical description is given, nor any figure.

Thomas[18] reported a small angioma of the bladder which was cured by fulguration. There was no pathological confirmation.

Caulk[19] reports two cases in his practice. The first, a tumour having " the appearance of an ordinary nævus ", occurred in a man, age 35. It was completely destroyed by the high-frequency current. No microscopic confirmation is given.

The second case was a woman, age 60, who suffered from hæmaturia. On vaginal examination there was a very hard indurated area on the vault of the vagina corresponding to the base of the bladder in the region of the trigone. This subsequently proved to be a large calcified lymph gland, which was located near the juxtavesical ureter and which was dissected out. Cystoscopically a peculiar condition of the left lateral wall near the ureteral orifice was observed. It had a mottled appearance, consisting of areas of blue and almost black spots intermingled with lighter cystic-looking masses. At the outer edge of the mass there was a typical telangiectatic spider-web dilatation of the blood-vessels. At operation it was possible to dissect out the whole tumour, which was found to encircle the lower portion of the ureter and was adherent to the adventitia of that tube. It consisted of irregular conglomerated masses of vascular dilatations which on pathological examination proved to be a characteristic hæmangioma of the cavernous type. The author regards this case as an angioma of the ureter, and it is apparently unique.

Katz[20] relates the case of a man, age 40, who complained of intermittent hæmaturia for six months. It appeared only at the end of micturition. The patient was an unfavourable subject for operation on account of cardiac and respiratory lesions, a moderate degree of anæmia, and bilateral renal stones. Cystoscopy revealed a bleeding point in the vicinity of the internal meatus, no blood coming from the ureters. Severe hæmorrhage compelled operative treatment, which took the form of cystotomy and

Paquelin cautery to the bleeding area near the internal meatus. Copious bleeding recurred within a few hours, and the patient died. Microscopical investigation showed "variously sized vascular lacunæ which were lined by endothelium . . . some of them penetrated the upper muscular layer". (Photomicrograph.)

Macdonald[21] showed a specimen of "nævus of the bladder" on Nov. 28, 1929, at the Royal Society of Medicine, which is included in their *Proceedings*. The tumour was excised in June, 1929, from the bladder of a male patient, age about 33. The only symptom was slight terminal hæmaturia, beginning about a month previously. Cystoscopy showed a tumour, apparently a nævus, growing from the left upper quadrant of the bladder. Microscopically the tumour is a cavernous angioma.

COMMENTARY.

There are, as we have seen, 20 cases on record in addition to the two reported here, though Broca's case was probably not an angioma. Of these 20 cases, only 8 have been confirmed by histological investigation. A surprisingly large number of cases—9—cannot claim histological confirmation, either because they were reported prior to the days of systematic submission of material to the pathologist, or because there was no open operation. Small nævi suitable for per-urethral diathermy will probably continue to appear in the literature without histological investigation. To this category belongs my first case, and also Thomas's and one of Caulk's cases. Moreover the same lack of confirmation will exist whenever treatment consists of cauterization through a suprapubic incision, as in Lane's and Katz's cases, the fear of hæmorrhage prohibiting the excision of portions for investigation. The diagnosis in all such cases must of course be accepted with reserve.

In the earlier literature a curious tendency is observed to confound vesical varices with true angiomata. It is necessary on this account to exclude various reports in which the lesion was obviously a varix. The *Encyclopédie française d'Urologie* calls attention to this: "Certain authors regard varices as tumours which should be ranged alongside angiomata. This opinion cannot be seriously defended. Varices are dilatations and vascular hypertrophies without new formation of vessels." Casper, however, reports an evident varix under the heading of an angioma, as do numerous other writers, and Sotti considers that the differentiation between the two is not always easy even after histological investigation. The differentiation, however, should be possible cystoscopically, and is important, because the clinical course of the two diseases is different. The bleeding occurs once or twice and tends not to be repeated when coming from a varix; whilst, as is evident from a study of our collected cases, the hæmorrhage from angiomata invariably recurs, is frequently profuse, and in four instances (Albarran, Langhans, Scholl, and Katz) led to death from exsanguination. Further, it may be considered justifiable to adopt expectant treatment in the case of varices, while more active measures are obviously required for angiomata.

The existence of nævoid tissue elsewhere was a striking feature in my second case. Extensive involvement of the colon, rectum and anus, thigh, scrotum, and penis was observed. In none of the other reported cases has there been such widespread hæmangiomatous tissue, though in four instances other nævi were reported. In Berliner's case a telangiectatic angioma the size of a walnut was present in the right labium, Lane's patient had venous lesions on the skin of the buttock, and Scholl's died of a hæmorrhage from the rectum, whilst Bachrach's patient had extensive nævi on the thigh and presumably a uterine nævus. Evidence of true cavernous tissue in other parts of the body must be sought for. It should be regarded as confirming the diagnosis of a cavernous tumour in the bladder, and helps in the differentiation of vesical angiomata from vesical varices. The simultaneous occurrence of angiomata in widely separated organs or surfaces is well known. Kramer,[22] in an article on angiomata, recorded 147 cases in which 28 per cent showed multiplicity of the lesions, and Ullmann[23] recognizes a condition of universal angiomatosis. Varices moreover occurring in the bladder are very prone to be associated with similar lesions—generally extensive—on the thighs, labia, etc.

My second patient also exhibited congenital deformities in the dislocation of the hip and the non-development of the right testis. It might have been expected that abnormalities would occur in other reports, but the only one which I have noted is that by Berliner, in which facial asymmetry was remarked.

Symptomatology.—A study of the recorded cases shows that hæmaturia is the outstanding symptom, though in many application for treatment was precipitated by the onset of vesical pain and frequency, which usually corresponded to the occurrence of infection. Once bleeding is established it tends to be continuous, or to recur at intervals and become increasingly severe. In several cases it was so profuse as to lead to a fatal issue, and in many cases to a severe grade of anæmia. The occurrence of nævi in other situations and of congenital deformities has already been discussed.

Treatment.—The treatment of these cases will vary according to their size and site. Per-urethral diathermy is suitable for small and obviously superficial tumours. It should be remembered, however, that the main bulk of the tumour, especially of the cavernous tumours, occupies the muscular planes (*see* Hübner, Sotti, Launay, and my own report), and that cauterization will almost certainly open up deep vessels which cannot be sealed by the electrode. Hæmorrhage following open cauterization recurred in Katz's case and terminated fatally.

Excision of the mass, as done by Launay, Hübner, Kidd, and myself, is a superior method when the circumstances permit. Apparently no anxiety need be felt regarding difficulty in hæmostasis when partial cystectomy is undertaken. In my own case the cut bladder wall appeared to be no more vascular than it does in ordinary circumstances, and Hübner and Launay observed and emphasized the same freedom from excessive hæmorrhage. An attempt should be made to remove the whole of the tumour and with it a fair margin of healthy tissue. In Hübner's case this was impossible, and a footnote added after the paper was in print showed that a recurrence had taken

place with severe bleeding, thermo-coagulation on three occasions being required to bring about a cessation of the symptoms.

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THE ANATOMICAL RESULT OF PERI-ARTERIAL SYMPATHECTOMY.

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Of recent years operative procedures upon the vasomotor nerves have been increasingly made use of in endeavouring to alleviate or cure a variety of clinical conditions. The principle underlying these operations is the physiological observation that division of the vasomotor nerves is followed by a peripheral vasodilatation. The usual method is to perform peri-arterial sympathectomy proximally in a limb with a view to causing increased vascularity distally. The results have been notably varied in all conditions for which the treatment has been tried, and the uncertainty of result may be correlated with our present lack of precise knowledge of the origin, distribution, and function of the vasomotor nerves. Experimental study of the vasomotor nerves in animals can yield useful information, but it has been noted (Woollard,[1] 1926) that the arrangement of the nerves varies in different species. Direct observation on human material is also called for. In order to supplement the information gained by ordinary dissecting methods (such as the work of Potts,[2] 1914, and Kramer,[3] 1914), no opportunity should be lost of making what amount to experimental observations, where possible, in material arising in the clinical use of sympathectomy operations. When it is subsequently necessary to resort to amputation, investigations of the anatomical result of the previous operation upon the limb may add to our knowledge of this difficult problem. It has been thought desirable to record even the limited observations made in one such case, in the hope of stimulating further similar investigations where opportunity offers.

History.—Mrs. P., age 57, was admitted to Mr. Duff's Surgical Unit at the Glasgow Royal Infirmary on Oct. 2, 1926. She had suffered from diabetes mellitus for twelve years and had been receiving insulin for one and a half years. Nine weeks before admission gangrene began in the right foot, accompanied by much pain.

On Admission.—The patient was in poor general condition and suffering severe pain. There was an area of moist gangrene the size of her hand on the dorsum and outer side of the foot, overlapping the external malleolus. The foot elsewhere was cold and blue, the vessels of the limb were sclerosed, and popliteal pulsation was just perceptible. The urine contained abundant sugar and albumin.

During the next two months the glycosuria was controlled by insulin, and local surgical measures were applied to the foot. Sloughs were gradually removed until a sluggish ulcer remained, making no progress. Morphia was occasionally required for the relief of pain. A trial of peri-arterial sympathectomy was decided upon, and the following extracts from the case record indicate the effect on the leg:—

Dec. 13.—Mr. Duff exposed the right femoral artery in Hunter's canal and injected absolute alcohol round the adventitious coat of the vessel. No immediate change in the foot was noted.

Dec. 14.—Foot appears decidedly warmer and colour is better. Pain is less. This progress was maintained during following days.

Dec. 20.—Granulations of ulcer are much healthier. Foot is warm and colour is good. Not much pain.

Dec. 28.—Foot continues to improve.

Jan. 6, 1927.—Improvement has ceased. Pain has returned. Foot feels colder.

Jan. 13.—Foot has relapsed to condition as before operation. Pain is severe. Amputation has been advised.

Jan. 17.—Mr. Duff amputated through thigh just above site of sympathectomy.

The limb was obtained immediately on amputation, and histological examination of the nerves on the main arteries was undertaken (D. M. B.).

The whole of the femoral artery was removed with its adventitia. It was estimated that the artery had been divided about one inch proximal to the site of previous alcohol injections, but owing to the necessary clearing of the adventitia to permit of ligating the vessel before dividing it, only a very short portion of artery with undisturbed adventitia was obtained above the injection site. The femoral trunk was split into longitudinal halves, one immersed in dilute methylene-blue solution for supravital staining, the other prepared by Ranson's method and divided into short lengths which were serially sectioned. An attempt to stain the remaining arteries of the limb with methylene blue by injection from the upper end of the popliteal artery was unsuccessful—probably owing to impermeability of the sclerosed walls. A block dissection of the popliteal artery and the upper ends of the anterior and posterior tibial arteries was, however, successfully stained by immersion. Pieces of both tibial arteries were prepared by Ranson's method. In addition, sections of all the arteries mentioned and of the peroneal artery were also stained with hæmalum and eosin in the ordinary way. By using both the supravital methylene-blue method and Ranson's method of nerve staining it was possible to examine the tissues both by dissection under the binocular microscope and by serial sections, and the results obtained by one method could be checked by the other.

Throughout all the vessels examined degenerative changes were widespread. There was much patchy calcification and apparent thinning of the tunica media, with asymmetrical thickening of the tunica intima. The peroneal artery was least affected, but in the lower parts of both tibials the intima was thickened all round almost to complete obliteration of the lumen.

With regard to the condition of the nerves accompanying the arteries, the extensive calcareous change in the vessel walls prevented study of the finer intramural arrangements of the vascular nerves, but the following points were established.

The longitudinal half of the femoral artery stained by methylene blue and dissected under the binocular microscope proved to contain the greater number of the larger vascular nerve-trunks (the asymmetrical distribution of these trunks was confirmed in sections taken from a normal human femoral artery). Four to five nerve-bundles could be made out, anastomosing with one another to form elongated meshes along the vessel. They ran in the inner face of the separated 'sheath' of the artery. (When an artery is 'cleaned'

its 'sheath' is separated by splitting the adventitia between the narrow inner zone of compact fibrous tissue and the wider outer zone of much looser texture.) Immediately above the site of injection the nerve-fibres were rather faintly stained, a few showing normally stained axons, but from the injection site downwards there was a complete absence of all axon-staining in the nerve-bundles. In sharp contrast to this, towards the lower end of the femoral artery appeared a small nerve-bundle with well-stained axons, running in to the adventitia from without, at first accompanied by a small artery. On penetrating deeper into the adventitia the fibres of this bundle appeared to distribute themselves distally within two of the main degenerated nerve-trunks. They were then difficult to follow, but were traceable to the lower end of the specimen.

The other longitudinal half of the femoral artery, stained by Ranson's method, showed similar features. Above the injection site three larger nerve-trunks were seen, all having a matted appearance, with loss of distinctness in the nerve-fibres and only a very few axons staining. In marked contrast with these, a fragment of the long saphenous nerve included in the block showed good normal staining. An occasional minute nerve-bundle immediately outside the muscular coat seemed normal. Below this level all the peri-vascular nerves identifiable in the sections showed degeneration, except two incoming twigs. The upper was accompanied by a small artery ; the lower approached the femoral artery immediately above the origin of a large muscular branch (? the anastomotica magna). Several fasciculi of the incoming nerve surrounded this arterial branch, which then appeared to carry off with it a comparatively normal nerve-supply. Only a small portion of the new nerve remained with the trunk of the femoral, its fibres ultimately becoming lost in the adventitia.

The popliteal artery (hæmalum and eosin sections) showed several larger nerves running into the outer part of the adventitia, all of normal appearance, with a preponderance of small medullated fibres, and all associated with small arteries. Deep in the adventitia were several smaller nerves, all showing degenerative appearances—the fibres seeming denser and more deeply stained than normal, and having blurred, irregular outlines. The lower part of the popliteal and the commencement of the anterior and posterior tibial arteries (methylene-blue dissected preparation) showed an abundant supply of nerves with well-stained axons, in marked contrast to the appearances seen in the femoral artery.

The posterior tibial artery had both normal and degenerated nerve-fibres in its wall. One large nerve running between the artery and its venæ comites contained well-stained axons except in one small degenerated portion. The normal fibres were chiefly of small medullated type, with a few large medullated fibres and some non-medullated fibres. The posterior tibial nerve, included in one block, showed, by contrast, a predominance of large medullated fibres. Deep in the adventitia were small nerve-bundles, some of normal appearance, others degenerated. All the nerves in this region (including the posterior tibial) showed thickening of the endoneurium, and in the adventitia of the artery were regions of small round-celled infiltration.

The peroneal artery showed a few small nerves in the adventitia, all of

normal appearance, without endoneurial thickening, and again with a preponderance of fine medullated fibres. No degenerated nerve-fibres were seen. The condition of the nerves upon the anterior tibial artery was not accurately ascertained. Some small nerves running deeply in the adventitia showed chiefly the fine medullated type of fibre.

These observations show that, although all the nerves running with the femoral artery at the seat of the original operation appeared to have been destroyed, fresh accessions of nerve-fibres arrived distally. A few small twigs joined the femoral artery in Hunter's canal, but the greatest influx of additional nerves occurred in the popliteal space. In all these incoming nerves whose composition could be definitely noted there was a predominance of fine medullated fibres (1·5 to 3 μ in diameter), with a few large medullated fibres (4 to 8 μ) and a distinct contribution of non-medullated fibres.

A special dissection of a normal human leg was undertaken (J. A. B.) to see how far the number and source of the incoming nerves to the blood-vessels could be recognized by ordinary macroscopic methods. The main vessels from the commencement of the common femoral artery to the level of the ankle-joint were dissected, together with the main nerves of the limb; great care was taken not to disturb the relations of these nerves to the arteries until all possible twigs from the former to the latter had been identified. The bones were disarticulated and shelled out from the muscles where necessary, to permit this being done. Every suspected nerve to an artery was carefully dissected out with the aid of binocular forehead magnifiers, and its origin from a nerve-trunk and true termination in the wall of an artery fully established. No nerves were found running to the sheath of the common femoral or the superficial femoral artery in Scarpa's triangle. In Hunter's canal two distinct twigs from the saphenous nerve joined the artery, one in the upper part of the canal, the other an inch and a half lower down. No supply from any other adjacent nerve was found. Immediately above the bifurcation of the great sciatic nerve there arose from the front of the nerve a long slender branch which appeared to lose some of its filaments in the connective tissue of the popliteal fossa; but the majority of its filaments were distributed to the sheath of the popliteal artery just above its bifurcation. This nerve could be traced into the internal popliteal division of the sciatic nerve. From the deep surface of the internal popliteal nerve there arose a definite leash of small nerves, of which some were distributed to the anterior tibial artery, but the majority went to the posterior tibial artery. Four small twigs from the posterior tibial nerve ran to the sheath of the posterior tibial artery in the middle two-fourths of the calf of the leg. No further twigs were found going to the anterior tibial or peroneal arteries.

The findings in the dissected and 'experimental' limbs correspond fairly closely, and are in general agreement with the results obtained by Potts (1914) in dissections of nerves to the arteries of the leg. Neither we nor Potts observed any vascular twig coming from the obturator nerve in the thigh. It seems a pity if the only vascular nerve in the leg which is mentioned in the ordinary text-books of anatomy has to be dropped.

This double source of vascular nerves—from the aortic plexus running peri-arterially into the limb, and incoming in the limb from the ordinary

nerve-trunks—was also recognized by Woollard (1926) in animals. In the cat, where he put the matter to experimental proof, the transition between the two types was found to occur about the level of the bifurcation of the common femoral artery. He thought the change might occur lower down in dogs. He states that the supplementary nerves were chiefly medullated, but that the peri-arterial trunks were almost entirely composed of non-medullated fibres. The nerve-trunks found with the upper part of the femoral artery in the case here examined were certainly not wholly or in great part non-medullated, but our investigation does not show how far these nerves may have come from the aortic plexus, or from, say, the femoral nerve above Scarpa's triangle. It seems to us rather that the nerves running peri-arterially into the leg, and those reaching the vessels distally from the nerves of the limb, are similar in structure. There is no sharp transition line indicating a proximal supply area belonging to the first set and a distal area belonging to the second set. Extensive overlapping occurs at least upon the main arteries, as we noted normal and degenerated fibres together on the lower part of the posterior tibial artery. The large degenerated peri-arterial trunks dissected in the coats of the femoral artery were obviously not by any means exhausted upon that artery. Such overlapping would help to explain the difficulty emphasized by Davis and Kanavel[4] (1926) of understanding "how the interruption of the minor portion of the vascular sympathetic innervation from a local segment of an artery can affect the most distal portion of the extremity".

But if there is no clear regional difference (in a proximo-distal sense) between the supply areas of the two sets of nerves, one or two features in the present investigation suggest there may be a qualitative difference in areas. It has been noted above that a muscular branch of the femoral artery in Hunter's canal seemed to be completely innervated from the peripheral source. Degenerated fibres were apparently absent on the peroneal artery, which is usually an almost purely muscular vessel: its nerve-supply also was derived from the peripheral nerves. On the other hand, the posterior tibial artery, a mixed muscular and cutaneous trunk, showed both degenerated and normal nerve-fibres. The suggestion is therefore put forward that the incoming nerves to the vessels in the limb may be specially concerned with the vascular supply to the muscles. It cannot be entirely so concerned, however, as Kramer (1914) has demonstrated fine accessory nerves running to the digital vessels in the hand. It is well known that the blood-vessels in the muscles themselves, down to the capillaries, receive nerve-fibres from the ordinary muscular nerves. It may be recalled that the blood-vessels in the muscles and of the skin show differing physiological reactions. Hoskins, Gunning, and Berry[5] (1916) have shown that adrenalin causes active vasodilatation in the muscles of the dog's leg, but vasoconstriction in the cutaneous vessels of the leg. Admittedly it is a matter of discussion how far the action of adrenalin on blood-vessels is mediated through the vasomotor nerves, but the striking difference of response in the muscular and cutaneous vessels calls for further investigation of any suggested difference in their nerve-supply.

The chief result of this investigation is to emphasize once again the dual paths of the vascular nerves to the limbs. It is obviously impossible to influence the whole of these by any proximal operation of peri-arterial

sympathectomy. Hence the preference of American surgeons—e.g., Davis and Kanavel (1926)—for cervical or lumbar sympathectomy operations in such cases is justified on anatomical grounds, apart from the desirability or otherwise, on general grounds, of the more severe type of operation then involved. Adson, at the Mayo Clinic, combines lumbar sympathectomy with peri-arterial sympathetic neurectomy of the common iliac arteries (Brown,[6] 1926). Cohen[7] (1925) admits the unsatisfactory result of peri-arterial sympathectomy in the thigh unless the femoral vein is ligated at the same time—which, of course, brings in a different method of treatment altogether; Brooke[8] (1927) also recommends this combined procedure.

A minor issue, perhaps mainly of theoretical import, may be mentioned. In the classical operative-surgery class-procedure of ligaturing a main artery in continuity, the student is taught to work very strictly within the 'sheath' of the vessel. Thereby surrounding structures are safeguarded; but if ever such an operation is required in real life and peripheral vasodilatation in aid of collateral circulation is desired, the opportunity is missed of securing such a possible temporary effect in this direction as would be obtained by section of the peri-arterial nerves. As has been shown, they run in the separated 'sheath'.

SUMMARY.

1. The condition of the nerves in the main arteries was investigated in a leg amputated five weeks after the peri-arterial injection of alcohol into the sheath of the femoral artery.

2. All nerves running with the artery at the seat of the previous operation appeared to have degenerated distally, but an abundant additional supply running to the vessels lower down from the ordinary nerves of the limb then showed up in marked contrast.

3. This accessory nerve-supply arrives upon the vessels of the leg mainly in the popliteal space. The incidence of these accessory nerves was also checked by anatomical dissection in another limb.

4. The incoming nerve-twigs have a characteristic structure, being composed chiefly of small medullated fibres, with a few large medullated fibres and a fair number of non-medullated fibres.

5. It is suggested that these incoming nerves may be specially concerned with the blood-vessels to the muscles.

We wish to record our thanks to Professor T. H. Bryce, F.R.S., for according us facilities for carrying out part of this investigation in the Anatomy Department of the University of Glasgow.

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OSTEOPLASTIC CRANIOTOMY.*

A NEW TECHNIQUE FOR THE RESECTION AND TURNING DOWN OF BONE-FLAPS FROM THE SKULL.

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With an Introduction

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INTRODUCTION.

The technique of osteoplastic craniotomy set forth in this paper appears to me to benefit materially this branch of surgery. In the following account of his operation Mr. Rogers describes a form of circular saw which has made the cutting of bone-flaps from the skull a very easy and safe procedure.

In first outlining his idea to me the author explained that in Australia he had been impressed by the rapid and accurate way in which wooden planks fed to a running circular saw were cut, and there appeared to be no reason why a similar principle should not be applied to the skull provided that adequate protection for the brain and its membranes was assured. I agreed with the application of the principle, and hence the 'skull plough', a name which was suggested because the finished appliance looked rather more like a disc plough than a timber-cutting saw. I have now seen the instrument in use on many occasions and am impressed with its simplicity and effectiveness in the performance of osteoplastic craniotomy. In a leading article on cranial incisions in the *British Medical Journal* for Feb. 25, 1928, we read, " The ideal incision is that which makes the operation easy, for what is easy is generally safe." Lambert Rogers's ' skull plough ', in appearing to fulfil these criteria, possesses advantages over other mechanical craniotomes which I have seen in use, and over such devices as Gigli saws.

It will be found that this paper is more than an account of a new craniotome and the method of using it. It embodies the result of much experimental work, not only in the methods of cutting bone—and particularly the skull with its tables and intervening diploë—but on the way in which fractures occur at the base of bone-flaps. It is well known that the difficulty in performing osteoplastic craniotomy is frequently not the cutting of the flap but the turning of it down. The author has contributed experimental observations to this subject which appear to throw much light on the question and to simplify the procedure.

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OSTEOPLASTIC CRANIOTOMY.

" Surgical technique is the most worthy and least regarded nowadays of all the essentials of good work, yet it is the one that most surely crowns our efforts with success."—*Lord Moynihan.*

Historical.—Although opening the skull is such an ancient operation that Velpeau remarked, " L'origine de la chirurgie cranienne se perd dans la nuit des temps ",[1] and examples of neolithic trephining, dating in all probability from before 2000 B.C.,* can be seen in many museums of anthropology, temporary resection of part of the skull by the formation of flaps comprised of its whole thickness—osteoplastic craniotomy—is of quite recent origin, having first been performed on a patient towards the close of the year 1889. Prior to that date the only form of temporary resection consisted of attempts—a few of which were successful—to replace the bone discs removed by trephining and in this way to close the skull completely at the conclusion of the operation.[2]

In 1864 Léopold Ollier[3] of Lyons suggested lifting up a piece of the thickness of the skull adherent to a flap of soft parts. Two years before that date flap operations had been performed on animals by Julius Wolff[4] in Berlin. But it was not until a quarter of a century after Wolff's experimental work and Ollier's suggestion that osteoplastic craniotomy was first undertaken on a living human subject. On Nov. 23, 1889, Wagner, of Königshütte, reported[5] a case upon which he had performed the operation which has since come to be known by his name. In his paper, " Die temporäre Resektion des Schädeldaches an Stille der Trepanation ", he described the operation which on Oct. 3 of that year he had performed upon a labouring man, age 27, who had been rendered unconscious by a coal-truck hitting him on the side of the head, and who two days after the accident had developed signs of hæmorrhage from the left middle meningeal artery. Wagner had previously experimented upon cadavers with the object of producing a bone-flap attached at its base to the soft parts so that the flap could be turned down, a reasonably large area of the brain exposed, and the flap subsequently replaced. He now applied this operation to his patient. A large bone-flap was chiselled out and turned down with its base still attached to the scalp, the extradural blood-clot was removed, the bleeding meningeal artery secured, and the flap replaced and sutured in position. Wagner's patient died twenty-four hours later, but the operation had introduced a new technique for the surgical exposure of the brain and its investing membranes, and it was not long before other and more successful attempts were carried out.

Methods of Performing the Operation.—Although some surgeons were hesitant to adopt the procedure, the advantages of osteoplastic resection of the skull were soon realized by others, who directed their attention to the best method of performing the operation. Wagner had used a hammer and

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* Dr. Wilson Parry (*Jour. Brit. Archæol. Assoc.*, 1916, March) believes that the operation was performed in the Carnac Epoch of the Neolithic Period, which probably ended in North-Western Europe about 2000 B.C., and Paul Broca (*Bull. Soc. Anthropol.*, 1876) gives sound reason for thinking that it was performed even before this, viz., in the Campigny or Early Neolithic Period.

chisel, but in his paper he sounded a note of warning against hammering owing to the possibility of producing injury to the brain.* He stated, "I only use small strong chisels and elevators, but perhaps some form of circular saw could be constructed which could be set in motion after the manner of a dentist's drill with which it would be possible to work more quickly and accurately." Circular saws had already been introduced into cranial surgery, but at this time Wagner was apparently unaware of them, and it was not until his paper was in print that he added a footnote to the effect that Richter had told him of a saw after the type he had suggested, constructed by Messrs. Collin, of Paris, and used by Péan and Ollier.

Circular Saws for Craniotomy.—Before the appearance of Wagner's "Die temporäre Resektion", however, our great pioneer of cerebral surgery, the late Sir Victor Horsley, had realized the desirability of having a mechanical method for rapidly cutting through the cranial bones, and his biographer, Stephen Paget,[6] writes that "so early as 1887 he added to the use of the trephine and the bone-cutting forceps the use of a miniature circular saw driven by a Bonwill's surgical engine" (*Fig.* 128).

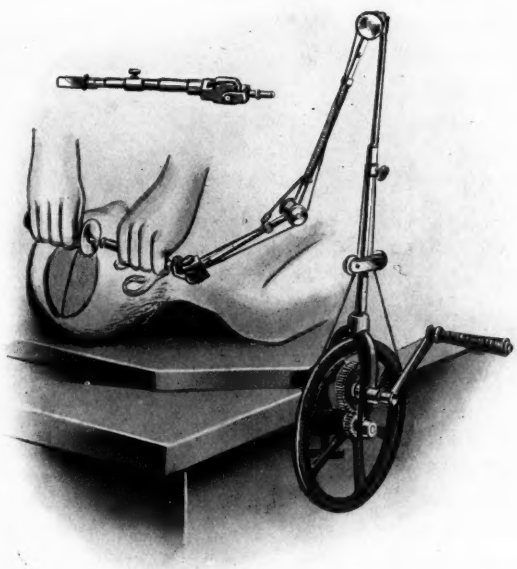

FIG. 128.—Sir Victor Horsley's circular skull saw. (*By the courtesy of Messrs. Mayer & Phelps.*)

About this time also Macewen in Glasgow was experimenting with a circular saw for craniotomy, but neither Horsley nor Macewen performed osteoplastic operations, nor did they find circular saws suitable for cranial work. It was not long before Horsley abandoned his, and in 1893 we find Macewen cautioning against the use of circular saws for opening the skull.[7]

In Paris, in 1897, Doyen introduced a circular saw for cranial surgery (*Fig.* 129),† and in the same year, in New York, William Waldo Van Arsdale, Adjunct Professor of Surgery at the Polyclinic, published a paper entitled

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* Gorodiski (*Ein Vorschlag zur Trepanation*, Erlangen, 1893), commenting upon this, states that for this reason the use of hammer and chisel for opening the skull was deprecated by Galen about A.D. 200.

† I am indebted to Messrs. Mayer & Phelps for kindly lending me the saws from which *Figs.* 129 and 130 are made and for kindly writing to Messrs. Collin, of Paris, about Doyen's saw. The following reply was received: "Nous avons l'avantage de vous faire connaître que la scie du Dr. Doyen a été construite par nous et présentée à la Société de Chirurgie vers l'année 1897."

"Remarks on Temporary Resection of the Skull by a New Method, with a Report on Three Successful Cases".[8] This new method consisted of the use of a specially constructed concavo-convex disc saw (*Fig.* 130), which Van Arsdale had presented to the New York Surgical Society the year previously, in the October of which he had also published an account of the instrument in the *Annals of Surgery*.[9]

Horsley's, Macewen's, Doyen's, and Van Arsdale's circular saws were all driven by surgical engines connected to their driving spindles by flexible cables; but apparently all these saws were failures, for not one remains in

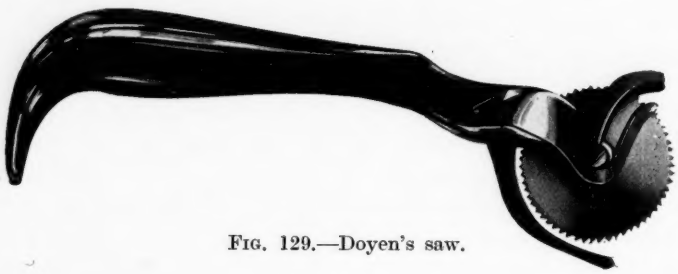

FIG. 129.—Doyen's saw.

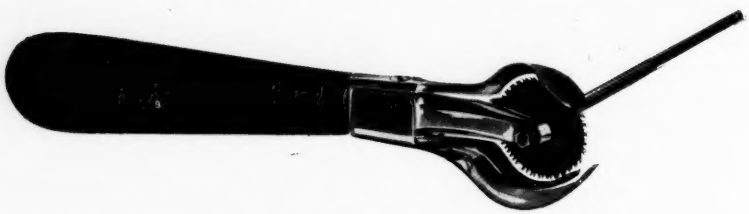

FIG. 130.—Van Arsdale's saw.

use to-day. Thus, for performing osteoplastic craniotomy, circular saws as constructed towards the end of the nineteenth century did not prove as useful as Wagner had hoped they might do.

Gigli Saws.—In 1894 a most useful instrument had been introduced by Leonardo Gigli, of Florence,[10] and the flexible roughened wires, now universally known as Gigli's saws and still in wide usage, very soon became popular: in action these saws resemble the old chain saws* which were introduced during the eighteenth century for cutting long bones.

Gigli saws are too well known to need detailed description here, and it will be generally conceded that cutting bone-flaps from the skull by their means is a very safe procedure, but a somewhat laborious and lengthy one, since a number of trephine or burr holes are necessary, the passage of the saws along guards introduced between these holes is tedious, and the wires frequently jam or break.

Mechanical Craniotomes.—From time to time mechanical craniotomes, many of which have been most ingenious and highly complicated machines, have been introduced into cranial surgery with varying claims as to the

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* Good examples can be seen in the Instrument Museum at the Royal College of Surgeons in Lincoln's Inn Fields.

advantages they possess in facilitating the performance of temporary resection of the skull. As examples of recent instruments, reference may be made to those of Jentzer, of Geneva,[11] De Martel, of Paris, and H. S. Souttar, of London.[12] There are disadvantages, however, appertaining to most mechanical craniotomes: some cut wide grooves, some concuss the patient, others tend to damage the meninges and the brain, while still others necessitate making holes in the centre of the bone-flap or are so complicated in their construction that it is conceivably quicker to open the skull with burrs and Gigli saws than to assemble and use the craniotomes. Further, most of these instruments require a good deal of preliminary handling and practice before it is justifiable to use them in the operating theatre.

The Problem of How to Improve the Gigli-saw Technique. — Although Sir Percy Sargent has developed a rapid method of cutting bone-flaps with drills and burrs, the use of a butcher's saw, and a few taps with a hammer and chisel, this technique obviously requires long practice and needs the hand of a master, and the first problem which still faces the great majority of surgeons who wish to expose the brain and its membranes through a replaceable bone-flap is how best to cut the flap with the greatest safety to the patient and the least distress to the surgeon. With the belief that the circular-saw method suggested by Wagner as a means of improving the technique of his temporary resection operation forms the solution of this problem, and despite the fact that this method of craniotomy had been unsuccessfully tried by many surgeons, including even Horsley and Macewen, some experimental work was undertaken with the use of circular saws.

An Albee's saw can, of course, be used very effectively, but this necessitates a number of openings into the skull and the passage of guards between them, and hence this technique proves very little, if at all, better than that in which Gigli saws are used. Attempts were therefore made to produce a simple craniotome, working on the circular-saw principle, and not requiring the preliminary passage of meningeal guards or the production of numbers of trephine or burr holes.

Examination of the circular saws which from time to time have been unsuccessfully employed for cranial surgery, and to some of which reference has already been made in this paper, reveals the fact that failure in each case has apparently been due to the difficulty of engaging a power-driven saw with the tables of the skull, while at the same time protecting the brain and the meninges from injury and maintaining an accurate directional and mechanical control over the instrument. This difficulty, however, was overcome by the production of an electrically driven disc-saw capable of accurately controlled biplanar movement, that in the vertical plane being towards and away from a flat guard which also serves as a separator to free the dura mater from the inner table of the skull. (*Figs.* **131–134.**)

The Circular Saw adapted for Osteoplastic Craniotomy.— The instrument which, from its superficial resemblance to a disc plough or cultivator, has been called a 'skull plough' consists essentially of three parts: (1) A pistol grip carrying the saw; (2) The guard and separator for the dura mater; and (3) A circular saw measuring $1\frac{3}{8}$ inches in diameter, driven in a clockwise direction by a flexible cable from an electro-motor. The saw is capable of

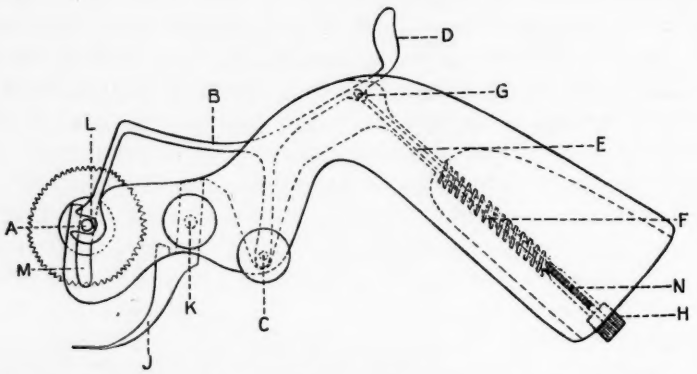

FIG. 131.—The 'skull plough': machine drawing—side elevation. **A**, Driving shaft of saw; **B**, Lever by which motion in a vertical plane is imparted to the saw; **C**, Fulcrum—a screw with milled head—from which the lever, **B**, acts; **D**, Thumb-push; **E**, Rod connected to lever, **B**, at **G** and carrying a thread, **N**, on which a milled screw, **H**, turns, controlling the degree of compression of a spiral spring, **F**; **K**, Screw with milled head fixing the dura mater guard, **J**, in position; **L**, Bearing for driving shaft of saw, moving through slot, **M**.

Note.—By unscrewing **C**, **H**, and **K**, the components of the instrument are easily taken apart for cleaning. The screw, **K**, permits angled guards to be inserted in place of **J** when it is desired to bevel the bone cut.

FIG. 132.—The 'skull plough': side view.

FIG. 133.—The 'skull plough': view from above and to the side.

movement in a vertical plane towards and away from the dura guard by pressure upon a thumb-piece against a spring which normally keeps the saw at the highest point of its vertical excursion, i.e., the maximum distance from the guard. The pressure on the thumb-push reduces this distance until, at its lowest point, the saw just clears the guard. The saw is capable also of movement in a horizontal plane by pressure forwards of the pistol grip, depression of which with the ball of the thumb also keeps the dura guard in close apposition with the inner table of the skull. These several features are illustrated in *Figs.* 131–134.* The motor develops about one-tenth of a horse-power.

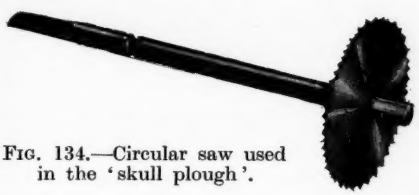

FIG. 134.—Circular saw used in the 'skull plough'.

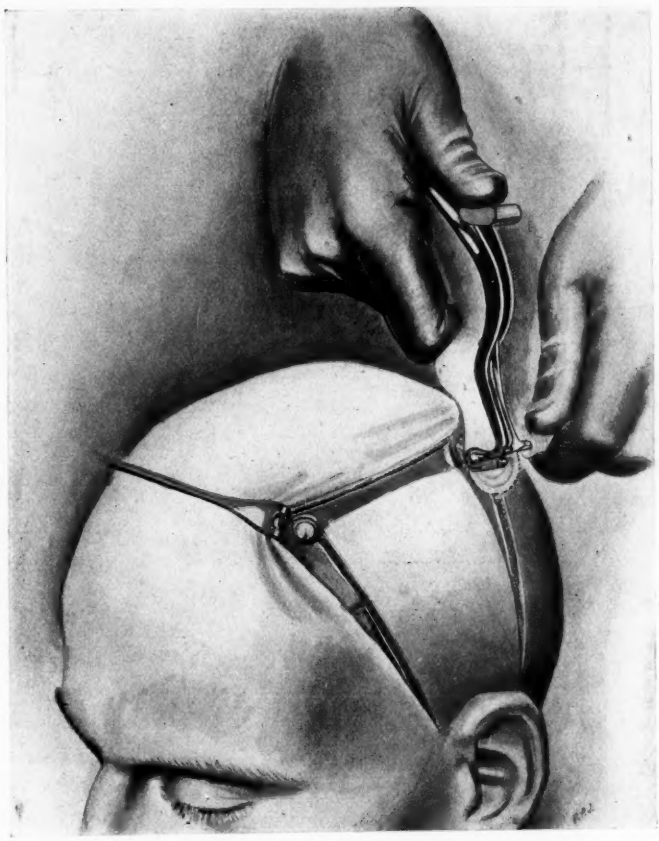

FIG. 135.—Method of using the 'skull plough' (partly diagrammatic). The soft parts have been divided down to the bone, the openings in the bone made, and the guard of the plough introduced through one so as to lie between the dura mater and the bone. The operator's right thumb is pressing the thumb-push downwards and forwards and engaging the saw, while the fingers of the same hand are around the butt of the instrument which, being depressed, keeps the dura guard closely applied to the inner table of the skull. The left hand steadies the driving spindle.

The Technique of Cutting and Turning Down Bone-flaps from the Skull.—The position and shape of the proposed bone-flap having been marked out, the soft parts are cut through along one limb of the flap, a heavy knife

* This instrument was demonstrated on July 24, 1929, to the Surgical Section at the Annual Meeting of the British Medical Association in Manchester, and has been made for me by Messrs. Mayer & Phelps, London, to whom I am much indebted for the patient way in which they allowed me to make alterations as the instrument evolved. I am also much indebted to Mr. P. G. Phelps of that firm for assisting me with certain mechanical problems involved in surgical instrument manufacture.

being used, and the tissues divided down to and including the pericranium (*Fig.* 135). While this incision is being made the hands of an assistant compress the edges of the wound and so control bleeding. Skin cloths are next fastened along the edges of the incision, using large Michel clips (No. 16)

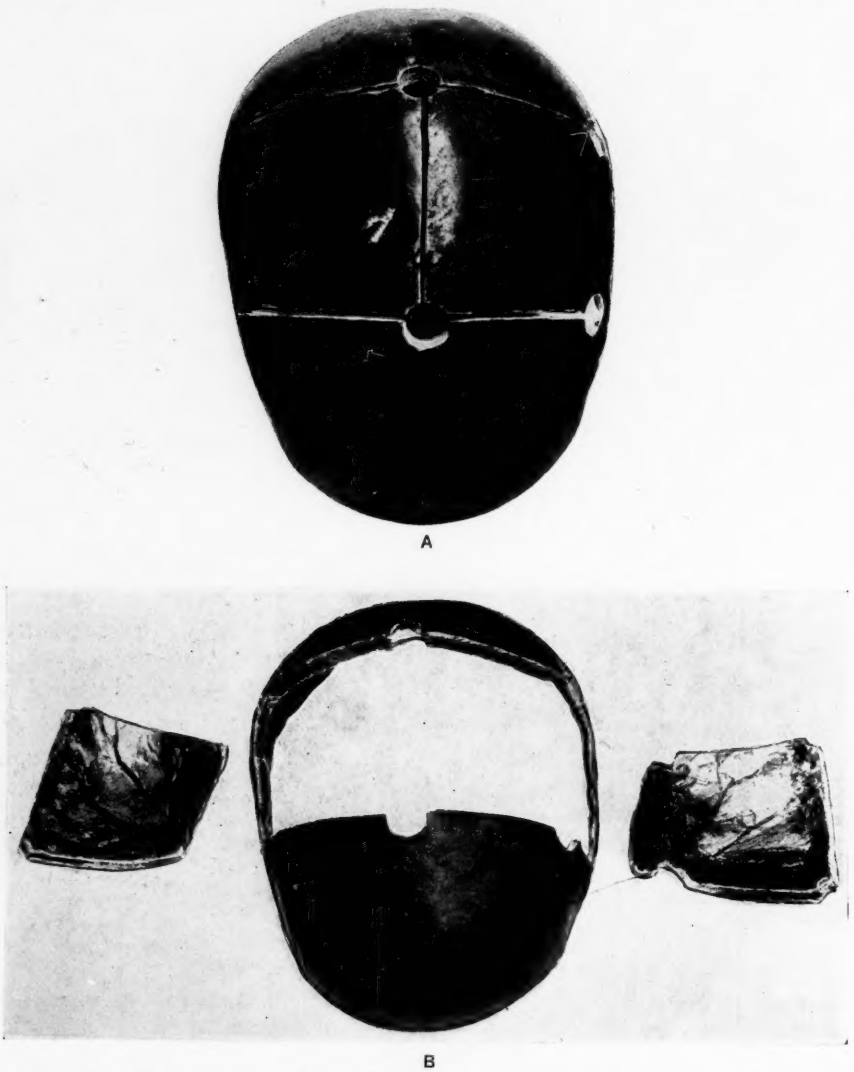

FIG. 136.—Experiment to show the way in which bone-flaps fracture. A, Two flaps of equal size and in corresponding position have been cut on the skull. The sides of the flap on the right terminate as saw cuts, those of the flap on the left as small circular holes (trephine or burr openings). B, Fracture of the two flaps has been produced. Note the comparatively straight fracture line of the flap on the right, and the jagged, irregular line between the trephine openings. This experiment has been repeated on numerous occasions and the results are consistent.

and taking a firm hold of the epicranial aponeurosis so that this is drawn outwards towards the cloths, and hæmorrhage is in this way completely arrested. The other two limbs of the flap are similarly dealt with, and two small ($\frac{3}{8}$ in.) trephine or burr holes are next made, one at each of the

meeting-points of the sides of the flap, the pericranium in this region being pushed away with a Farabeuf's raspatory, prior to drilling. The guard of the 'skull plough' is next passed through one opening, the saw being at the position of maximum vertical height, which is such that the thickest skull can be cleared, and the guard is made to lie between the dura and the inner table of the skull, and directed in the line of the proposed section of the bone. The pistol grip is now depressed so that the guard is kept closely applied to the inner table, and the saw, which is being rapidly rotated by the flexible drive from the motor, is engaged by gradually depressing the thumb-push, while the whole 'plough' is gently and evenly propelled along the desired line of section. To stop cutting, it is only necessary to relax the pressure of the thumb upon the thumb-push, when the saw, still of course rotating, rises out of the groove which it has been cutting.

FIG. 137.—Osteoplastic flap cut from a cadaver with the 'skull plough'. A, Flap in position; B, Flap turned down. Note the straight line of fracture at the base of the flap.

Engaging the running saw with the bone is somewhat akin to 'letting in' the clutch of a motor-car, and must be gentle and gradually progressive to prevent the load becoming suddenly too great and the engine stalling. If this precaution is taken, this type of circular-saw craniotome has been found to work smoothly and rapidly, and the three limbs of a large bone-flap can be cut in a few minutes. Also, by using angled meningeal guards the flap can be cut with bevelled edges, and very accurate apposition effected when at the end of the operation it is desired to replace the bone. By cutting the bone-flap so that two of the limbs converge towards the base (*Fig.* 135), it has been found that the flap can be fractured easily at its base and that it breaks along an approximately straight line joining the termination of the saw cuts (*Figs.* 136, 137 B). This line of fracture tends to be remarkably regular,* and more so than when trephine or burr holes mark the ends of the line along which the bone is broken, as is necessary in using the Gigli-saw technique (*Fig.* 136).

* An explanation of this has been given me by my colleague, Mr. J. E. Barlow, Lecturer in Engineering in Cardiff College, who points out that the concentration of stress around the trephine or burr openings would be much greater than around the ends of saw cuts.

Before applying this technique to a living subject, experiments were undertaken with the instrument in the dissecting-room* (*Fig.* 137 A, B), and it was not until June 3, 1929, some six months after designing the 'skull plough', that osteoplastic craniotomy on a living patient was first performed with it. It has now been used upon a number of cases under either general or local anæsthesia (*Figs.* 138, 139), and has proved so advantageous for performing Wagner's operation that it appears to fulfil his prediction as to the value of a circular saw for this purpose. A recent case will illustrate this:—

A well-developed farmer, age 33, was admitted to the Royal Infirmary in a very restless condition of semiconsciousness following a blow on the left side of the head with a ploughshare. Intracranial tension was kept reduced by four-hourly rectal injections of 30 per cent magnesium sulphate. There was no lucid interval followed by coma, but three days after his admission right monoplegia developed and soon progressed to hemiplegia. The systolic blood-pressure was only 90 mm. of mercury.

FIG. 138.—Patient six days after production of an osteoplastic flap by the technique described.

Five days after the accident, under chloroform–ether–oxygen anæsthesia, an osteoplastic flap, with its base beneath the temporal muscle, was turned down over the left motor area, a linear fracture traversing the parietal and squamous temporal bones was exposed, and 83 grm. of extradural blood-clot resulting from torn anterior branches of the middle meningeal vessels were removed. The bone-flap was cut with the 'skull plough'. Following the evacuation of the blood-clot, the flap was replaced and sutured in position. The systolic blood-pressure at the end of the operation was still 90 mm. of mercury. The patient made a complete recovery, power in the leg returning first, followed by that in the arm. (*Fig.* 138.)

This example of left middle meningeal hæmorrhage resembles in many respects that upon which Wagner in 1889 was the first to perform osteoplastic

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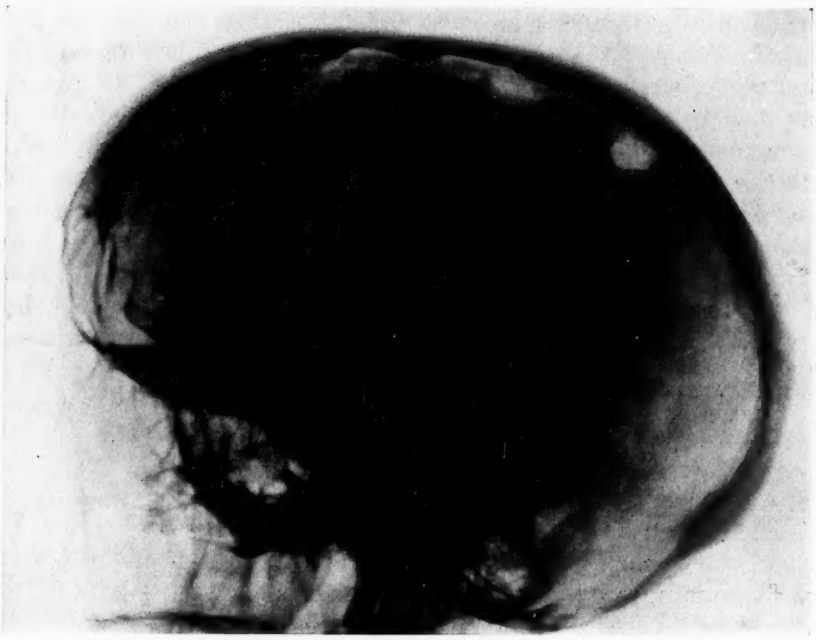
* I am indebted to Professor C. M. West for giving me facilities to perform these experiments.



Lateral view.

Antero-posterior view.

FIG. 139.—X-ray appearances after replacing osteoplastic flap cut with 'skull plough' The patient was a woman, age 52, with Jacksonian epilepsy.

craniotomy, using a chisel to cut his bone-flap, while suggesting that some form of surgical saw might be constructed to serve the purpose better. It will be remembered that Wagner's case was one of left middle meningeal hæmorrhage occurring in a labouring man of 27.

Advantages of the 'Plough' Technique.—The advantages claimed are:—

1. Rapidity of execution. Although in some clinics there would appear to have developed a surgical fashion of working very slowly at intracranial operations, sometimes prolonging them to a remarkable length of time, which must be a severe test of the stamina of both patient and surgeon, there seems to be little in favour of this attitude, and much against it. The shorter the time during which an operation wound is open, the fewer the chances of infection and the sounder the healing when the wound surfaces are approximated. Time-saving, therefore, must obviously be of importance provided it can be effected without danger to the patient.

2. When cutting the osteoplastic flap there is absolutely no danger of injury to the meninges or the brain, and thus the technique is a safe one.

3. There is an absence of any concussing force liable to produce cerebral contusion, such as occurs in the 'punching-out' type of craniotomes.

4. There is no need, as with some craniotomes, to trephine the centre of the proposed flap. A central opening in the bone is obviously a disadvantage if a flap is being turned down over a vascular meningeal tumour with overlying changes in the bone, since there may be troublesome hæmorrhage during the cutting of the flap.

5. The grooves made in the bone are narrow, and the flap can be cut with one or all of its edges bevelled so that it can be accurately replaced at the conclusion of the operation.

It is believed that the accurately controlled biplanar action of the 'skull plough' constitutes a new principle in the use of circular saws for surgical work, but the instrument is essentially so simple that it is surprising it has not been devised before. Although at first sight, and to those who have not seen the 'plough' working, it may appear rather complicated, it is not so really, and its successful action appears to depend on its essential simplicity. Lord Moynihan has said that "in the craft of surgery the master word is simplicity",[13] and the technique of osteoplastic craniotomy as here set forth has been evolved with this ideal in view, the 'skull plough' being the result of attempts to produce the simplest and at the same time a perfectly safe method of adapting the circular saw to work in the way in which Wagner originally suggested osteoplastic craniotomy should be carried out.

CONCLUSIONS.

An attempt has been made to solve the problem of how to improve the technique of performing Wagner's operation of osteoplastic resection of part of the skull. It is believed that this problem has been solved by adopting Wagner's original suggestion to cut the bone with a circular saw, an instrument having been produced involving a principle which surmounts the difficulties that are inherent in the circular saws which

have previously been tried for this purpose, and which have failed because of these difficulties.

The 'skull plough', in facilitating the performance of the Wagnerian operation, adapts the circular saw to craniotomy in a manner which enables a bone-flap to be formed in a few minutes with both accuracy and absolute safety. Moreover, this bone-flap can be turned down easily—fractures along a straight line constituting its base—and at the conclusion of the operation can be accurately replaced and sutured in position.

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PURPURA AS AN ACUTE ABDOMINAL EMERGENCY.

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PURPURA is a disease of great interest and importance to the surgeon. It forcibly intrudes into his diagnostic arena; on rare occasions it is the cause of an intussusception; it may give rise to profound hæmaturia or alarming hæmorrhage from a mucous lining of the body; it is a condition which calls for blood transfusion, and evidence is accumulating rapidly that certain carefully selected cases are permanently benefited by splenectomy.

In the past purpura has been divided into various types: (1) Purpura simplex; (2) Purpura rheumatica or Schönlein's disease; (3) Purpura abdominalis or Henoch's purpura; (4) Purpura hæmorrhagica or morbus maculosus Werlhofi; (5) Purpura fulminans. These subdivisions are incomplete, confusing, and unnecessary. Variations in symptoms are due to the location of the hæmorrhages. On this account Morse and Stone plead that these names should be dropped, and that in future we should speak of one clinical disease—purpura, with hæmorrhages and symptoms in various situations.

In this communication it is proposed to consider purpura from the standpoint of an acute abdominal emergency.

The Diagnosis of the Rash.—Purpuric spots have many times been mistaken for flea-bites, thereby confusing an important diagnosis. In the case of the extremities this mistake is hardly forgivable, for the spots of purpura are always maximally aggregated on the extensor surface. When the trunk alone is affected the differential diagnosis is more complex. In doubtful cases the tourniquet should be applied.

The Tourniquet Test.—When a rubber catheter is tied rather tightly around the arm of a patient suffering from purpura, petechial hæmorrhages appear distal to the constricted area. The tourniquet should be left in position for three minutes.

Hæmorrhage into the Wall of the Small Intestine. — Extravasation of blood into the wall of the gut gives rise to peritonism. Subserosal hæmorrhages in particular interfere with normal peristaltic action and produce symptoms of intestinal obstruction.

Case 1.—A boy of 8 was admitted in a very collapsed condition, with a diagnosis of intussusception. He presented a typical picture of advanced upper-gut obstruction. The eyes were sunken, the tongue was dry and brown, the pulse poor. He was vomiting ceaselessly. The note from his doctor stated that there was an ill-defined lump immediately above the umbilicus, which was confirmed. On turning the patient on his side to make a rectal examination it was noted that the buttocks were covered with purpuric patches, some of which were the size of a two-shilling piece. Purpuric patches were seen also on the back, and particularly on the lobules of the ears. In addition a number of small spots on the extremities and the

abdomen were observed. The diagnosis of purpura was evident, but it was thought that there was a concomitant intussusception. The abdomen was opened, and a most astonishing picture was revealed. About four feet of jejunum was the colour of bright-red blood (*Fig.* 140), and on closer examination extravasated blood could be seen beneath the serosa. The whole of this area was heavy with blood. No intussusception or obstruction was found. The abdomen was closed. The patient was given rectal saline during the night. Calcium lactate was administered later. Recovery.

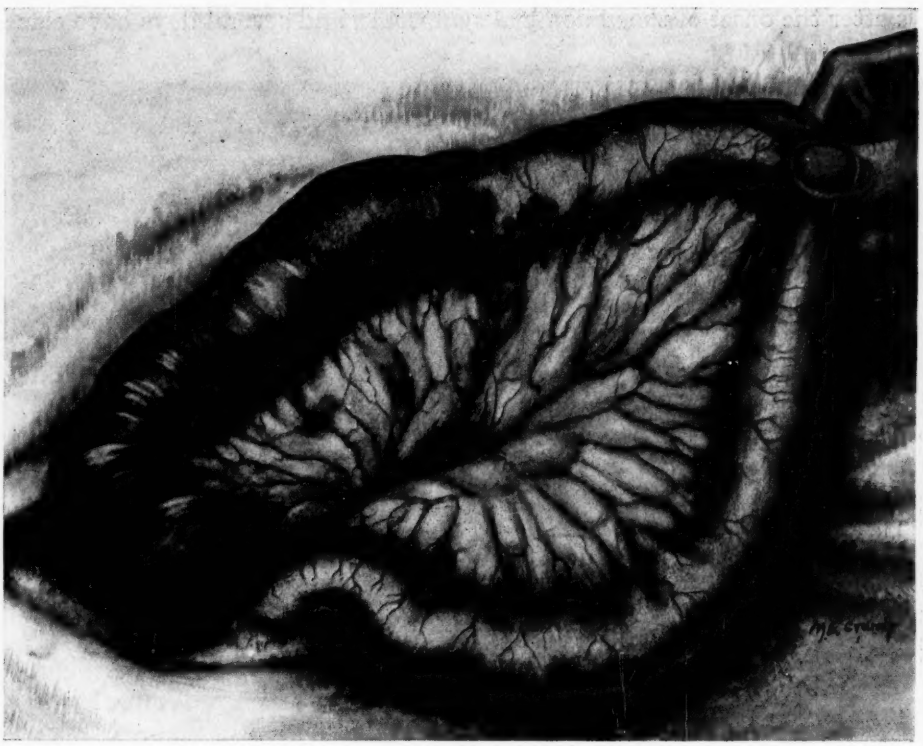

FIG. 140.—*Case* 1. Subserosal extravasation of blood in purpura.

Case 2.—H. A., age 21, was sent to hospital as acute intestinal obstruction. He stated that he had had acute abdominal pain for forty-eight hours. The pain was spasmodic in character, and he had vomited copiously and repeatedly. On the table beside him was a receiver containing bile-stained vomit which he had just ejected. On inquiry it was elicited that one year previously he had had a similar attack lasting three days, and he volunteered the information that on that occasion he thought he had passed blood in the motions. The temperature was 98° and pulse 68. Preparatory to an abdominal examination, while the nurse adjusted the bedclothes the patient grasped the bedrail above his head, and in so doing exposed a large bruise on his arm. This was fortunate, for an examination of the limbs showed a typical purpuric rash (*Fig.* 141). Deep tenderness in the epigastrium was the only physical sign on abdominal examination. The rectal examination was negative. The diagnosis of purpura with submucosal hæmorrhage into the jejunum was made, and it was resolved to open the abdomen if the symptoms continued. As it happened, the abdominal pain and vomiting subsided within an hour, and in a fortnight the rash had faded almost completely. Some months later the patient was again admitted with similar symptoms, and he stated that attacks of colic

and vomiting had recurred at weekly intervals. As the platelet count was low, after three weeks' rest in bed the spleen was removed after preliminary blood transfusion. Ten months later the patient wrote to say that he had been quite free from colic and was at work, although the rash appeared if he allowed himself to become constipated.

As can be culled from *Table I*, a hæmorrhage into a limited portion of intestine often gives rise to a palpable tumour. Sometimes the abdominal symptoms precede the rash; in a case of Gracie's the rash came out eleven days after the onset of the abdominal symptoms, and several days have elapsed

FIG. 141.—*Case* 2. Showing the rash and the bruise which called attention to the condition. The patient appeared to be suffering from acute intestinal obstruction when first admitted.

in the cases reported by Osler, MacGillivray, and others. Little wonder, then, that surgical clinicians sometimes diagnose acute intestinal obstruction, intussusception, mesenteric occlusion, or some other intra-abdominal catastrophe normally requiring immediate operation, and open the abdomen only to find a collection of blood in the wall of the small intestine.

Several observers have likened the affected segment to stiffened gut after an intussusception has been reduced, but I take it this alludes to what is felt on palpation. The only condition which *looks* somewhat like the bloody extravasation of purpura is mesenteric thrombosis. In the case of purpura in which I opened the abdomen the affected gut presented an appearance which may be reproduced exactly by injecting arterial blood under the serosa.

Table I.—Cases in which Laparotomy was Performed and Hæmorrhage into the Wall of the Intestine Found.

Author	Sex	Age	Diagnosis	Operative Findings	Result
1. Greig	M.	9	Intussusception (lump palpable)	Hæmorrhage into wall of small intestine	R.
2. Murray, reported by Sutherland	M.	5	Intussusception (lump palpable)	Hæmorrhage into wall of ileum near ileocæcal valve	R.
3. Cook	M.	12	Intussusception (lump palpable)	Hæmorrhage into wall of small intestine	D.
4. Pybus	F.	9	? Intussusception (no lump)	Hæmorrhage into wall of lower ileum	R.
5. Fitzwilliams	A child		Intussusception (lump palpable)	Hæmorrhage into wall of lower ileum	D.
6. Kennedy	M.	9	Intussusception (lump palpable per rectum)	Hæmorrhages into wall of small and large intestine	R.
7. Dive and Purkiss	M.	19	Intussusception (lump palpable)	Hæmorrhage into wall of small intestine	D.
8. Mills	M.	16	Chronic intussusception	Patches of œdema and hyperæmia along the small intestine	R.
9. Burrows	M.	11	Intestinal obstruction	Hæmorrhage into wall of ileum	R.
10. Hadley	F.	19	?	Hæmorrhage into greater part of wall of jejunum	R.
11. Molesworth	F.	15	Appendicitis	Hæmorrhage into wall of small intestine	R.
12. Machol and Sthamer	M.	13	? Appendicitis	Hæmorrhage into ileum. Multiple hæmorrhages under peritoneum over mesenteric glands	D.
13. Harrigan	F.	13	? Appendicitis	Hæmorrhage into wall of lower ileum	R.
14. Patterson, reported by Hunter	M.	50	? Perforated gastric ulcer	Extravasation of blood into wall of jejunum	D.
15. Widgery	M.	23	?	Hæmorrhage into wall of small intestine (ileo-ileostomy performed	R.
16. Bailey	M.	8	Intussusception (lump palpable)	Hæmorrhage into wall of jejunum	R.

R. = Recovered D. = Died.

The sheen of the serosa is heightened; moreover, on gently touching the serosa it can be made to move on the underlying blood.

Table II.—Intussusception Complicating Purpura.

Author	Sex	Age	Type of Intussusception	Operative Treatment	Result
1. Vierhuff (1893)	M.	29	Ileocæcal	No operation	Intussuscepted portion of bowel passed per rectum
2. Sutherland (1896)	F.	7	Ileocæcal	No operation	D.
3. Lett (1908)	M.	3	(*a*) Ileocæcal (*b*) Ileo-ileal (recurrence)	(*a*) Intussusception reduced (*b*) No operation	D. 9 days after reduction of first intussusception
4. Morse and Stone (1909)	F.	7	Ileocolic	Intussusception reduced	R.
5. Collinson (1910)	M.	4	Ileo-ileal	Intussusception resected	R.
6. Robinson (1910)	M.	5	Ileo-ileal	Intussusception resected	R.
7. Tonking (1910)	M.	5½	Ileo-ileal	Intussusception reduced	R.
8. McKechnie (1911)	?	2	Ileo-ileal	Intussusception reduced	R.
9. Gara (1912)	M.	5	Ileocæcal	No operation	D. Intussusception found at autopsy
10. Barling (1913)	M.	4	Ileocæcal	Intussusception reduced and affected bowel resected	R.
11. Lederer (1913)	M.	2	?	No operation	Intussuscepted portion of bowel passed per rectum
12. De Lavergne and Guillemin (1927)	M.	21	Ileo-ileal	Intussusception resected	D.
13. Caizergues (1929)	F.	3	Ileo-ileal	Intussusception reduced	R.
14. Ballin and Morse (1930)	M.	31	Ileocæcal	Intussusception reduced	Operation successful, but died of hæmaturia 2 months later

Acute Intestinal Obstruction Following the Subserosal Extravasation of Blood.—

H. A. Donaldson's case.—The patient, a boy of 11, had an attack of purpura with acute abdominal symptoms, and passed blood per rectum. During convalescence he had a sudden attack of acute intestinal obstruction. Laparotomy was performed forthwith. About five feet above the ileocæcal valve was a tubular constriction of

the intestine half an inch in length. All other structures were normal, and there was no Meckel's diverticulum. Lateral anastomosis was performed and the patient recovered.

Donaldson considers—very rightly, I think—that the constriction was the direct result of the extravasation of blood. Cicatrization about the intestinal hæmatoma is a potential late complication of purpura with abdominal symptoms.

Purpura and Intussusception.—A submucosal hæmorrhage tends to produce an excrescence protruding into the lumen of the intestine; obviously, such an excrescence invites intussusception. Up to the time of Hugh Lett's classical paper in 1908 no case of intussusception following purpura had been submitted to laparotomy. Since that time nine cases so treated have been reported (*see Table II*). Of these, seven have recovered completely. In no fewer than four instances has it been necessary to resect the intussusception; three of these four patients recovered, which is a tribute to surgical progress. On the other hand, as the intussusception was found to be gangrenous or irreducible in nearly half the total number of cases submitted to laparotomy, one is driven to the conclusion that there had been undue delay in opening the abdomen.

Purpura with Intestinal Symptoms. Selecting Cases for Laparotomy.—To diagnose purpura before the rash has appeared is manifestly impossible, and laparotomy will occasionally, and quite rightly, be performed in those cases which mimic an acute abdominal emergency. To overlook a purpuric rash or to mistake it for flea-bite is an occasion for self-criticism, but the question with which we are principally concerned is what course to pursue when purpura is evident and a concomitant intussusception suspected. An ill-defined lump (*see Table I*) is but a feeble guide to the necessity for laparotomy, yet to miss an intussusception must be our constant fear. The pinnacle of misfortune in this respect was reached by Sutherland. He advised laparotomy in his first case, and an extravasation of blood was found. On the next occasion he persisted in medical treatment, to be rewarded by the demonstration of a gangrenous intussusception at necropsy. In spite of the rarity of intussusception, most of us will agree that it is better to explore. This would be universally accepted if the patient's exit had not been hastened by bleeding from the wound, as occurred in two of the reported, and probably in several unreported, cases. If laparotomy was followed in a day or two by blood transfusion, this reproach would be removed.

After-treatment.—All patients who survive an attack of purpura should be carefully followed up. In chronic or recurrent cases the advisability of recommending splenectomy should receive full consideration. As far as our knowledge goes at present the most valuable guide is the platelet count. To quote Cohn and Lemann—"A diminished platelet count bears the same relationship to purpura as a fall of blood-pressure does to shock, or the thermometer to a febrile reaction. The platelets are the indicators." They indicate that the patient will, probably, be benefited by removal of the spleen.

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THE MIXED TUMOURS OF THE SALIVARY GLANDS.

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INTRODUCTION.

The salivary glands, more especially the parotid, but also to a lesser extent the submaxillary and other smaller glands, are the not infrequent site of an interesting series of tumours, which in this country are generally known as 'mixed tumours'. The tumours of this group show many variations of histological structure, and as a result we find applied to individual examples in the literature, in accordance with the particular appearance noted, such terms as 'myxoma', 'fibro-myxoma', 'fibro-myxo-endothelioma', 'endothelioma', 'adenoma', 'adenoid cystic epithelioma', 'chondroma', 'chondro-carcinoma', and 'cylindroma'. The confusion of terminology is aggravated also by lack of agreement on the derivation of the tumours. Among the numerous suggestions made, it has been argued that they are epithelial, that they are endothelial, that they are derived from sequestrated collections of embryonic cells or from some portion of the branchial arches, and that they have a truly mixed origin. So much of the recorded work deals with this question of derivation that more practical issues have been rather neglected and obscured by a mist of hypothesis. A certain number of efforts, however, have been made to evolve a pathological classification which shall be of practical value in indicating to some extent the probable clinical course of a given tumour, and the prognosis after operation. Thus Wood[1] (1904) classified his cases into three groups: (1) Hard, fibrous, and acellular tumours; (2) Cartilaginous tumours; (3) Cellular tumours. The first two groups he regarded as relatively benign, and the last as relatively malignant, but no figures are given in support of these conclusions, and the classification is also unsatisfactory in other ways. Wilson and Willis[2] (1912) subdivided their cases in a similar manner. Of 9 cases of recurrence in 42 patients traced in their series, 5 were classified as being of the cellular 'sarcomatous' type, and 4 as of the 'fibrous' type.

From such work as has appeared on the subject, the general impression seems to be that there are two chief types of tumour: (1) A soft, highly cellular tumour liable to recur after operation; and (2) A harder acellular, fibrous tumour, operative removal of which will probably be followed by prolonged freedom from recurrence. The views of McFarland[3] (1926), however, form a notable exception. As the result of a study of 90 cases, this observer came to the conclusion that no relation could be established between the histological and clinical features of parotid tumours, and that "the microscope, beyond showing that the lesion is a mixed tumour, is misleading rather than enlightening".

SCOPE OF THE PRESENT INQUIRY.

We are thus in the position of having to deal with a group of tumours the derivation of which is a matter of dispute, concerning the terminology of which there is no general agreement, and of which no satisfactory pathological classification has yet been determined. The main aim of the present inquiry was to see whether a histological classification could be evolved which would allow of some degree of correlation of the clinical and pathological features, or whether the two were entirely unrelated as claimed by McFarland. The objects of the paper are thus primarily practical, though at the same time the conclusions formed during the course of the study on such theoretical questions as the derivation of the tumours will be given, together with the evidence on which these conclusions are based.

Material and Method of Study. — The material consisted of 55 cases of 'mixed tumours' of the salivary glands treated in the wards of the Middlesex Hospital since 1919, and of the pathological material from 52 of these cases which was available for study in the Bland-Sutton Institute of Pathology. In addition, a certain number of fresh tumours removed outside the hospital have been examined. The pathological and clinical aspects of the study were at first kept quite separate, and it was only after the pathological investigations had been completed that the task of tracing the after-histories of the patients was begun. The after-histories in the case of the patients traced are correct to the end of July, 1929.

The results of the investigation may be conveniently considered under the following headings: (*I*) *The histological appearance of the tumours;* (*II*) *Their clinical course;* (*III*) *The correlation of the clinical and histological findings.*

I. THE HISTOLOGICAL APPEARANCE OF THE TUMOURS.

It will be convenient to begin by describing the microscopical appearances of a 'typical' mixed tumour. Such a tumour is composed partly of collections of cells, partly of myxomatous tissue, the two elements being intermingled in varying proportions in different parts of the same tumour, while the whole tumour is as a rule enclosed within a well-defined fibrous-tissue capsule (*Fig.* 142). A characteristic microscopical field is illustrated in *Fig.* 143. One sees collections of cells with small dark angular nuclei arranged in irregular masses and branching columns, while between the cellular areas is a myxomatous tissue. There is usually no abrupt demarcation between the cellular and the myxomatous areas, the histological appearances suggesting very strongly that the myxomatous areas are being derived from the cellular areas. Though the collections of cells for the most part show no tendency to arrange themselves in any definite structural

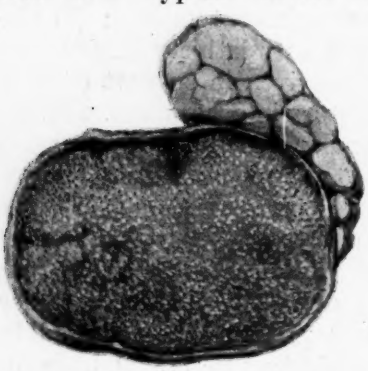

FIG. 142.—Typical encapsulated mixed tumour from the submaxillary gland.

formation, yet in nearly all tumours may be found areas such as those illustrated in *Fig.* 144, in which an alveolar or ductal arrangement is reproduced. In different tumours greater or lesser numbers of cells will show this arrangement, while in some—as, for example, the one from which the illustration was taken—the process may take place to such an extent that an appearance is produced not unlike that found in a fibro-adenoma of the breast. On the other hand, in some cases the cell masses have almost entirely disappeared, the greater part of the tumour being composed of myxomatous tissue. Such a tumour is illustrated in *Fig.* 145, and it will be seen that, apart from a thin layer of cells at the periphery, practically the entire tumour is myxomatous. We may thus say that a 'typical' mixed tumour is formed histologically of three elements in varying proportions : (1) Collections

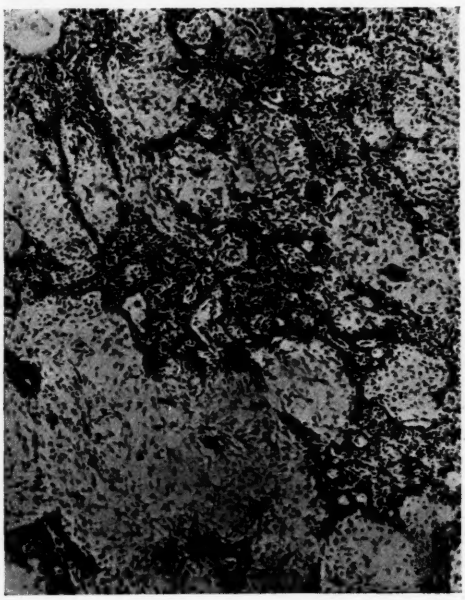

FIG. 143.—Typical parotid tumour showing masses and columns of cells containing small dark angular nuclei, and intermediate myxomatous areas with similar cells. (× 60.)

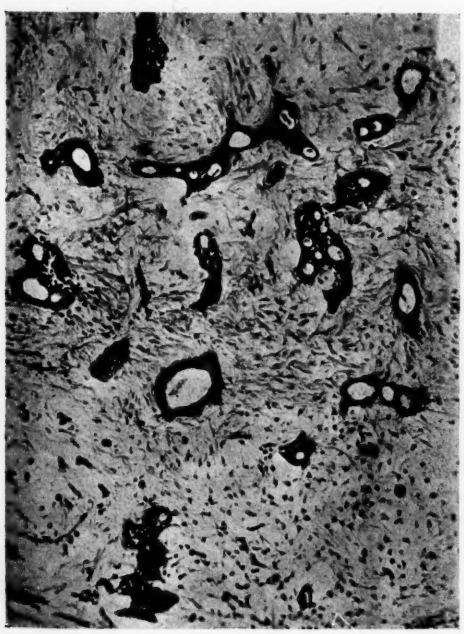

FIG. 144.—A tumour from the parotid, in which the cells are tending to arrange themselves in adenomatous formation. In between is the usual myxomatous tissue showing fibrillar condensation. (× 60.)

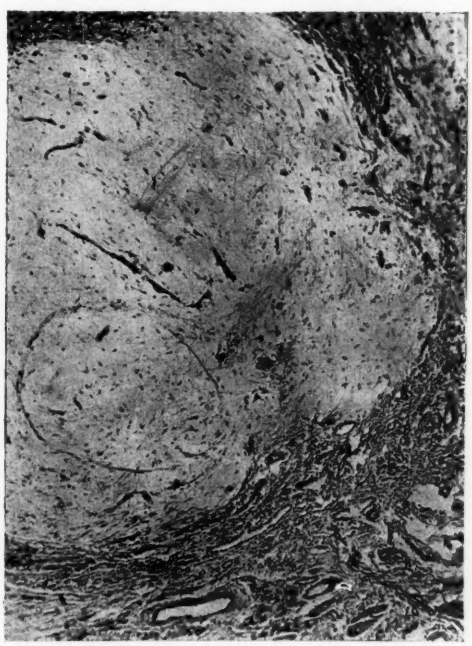

FIG. 145.—Tumour which has undergone almost complete myxomatous change, a thin layer of cells at the periphery alone remaining. (× 40.)

of cells without definite arrangement; (2) 'Adenomatous' areas; (3) 'Myxomatous' areas. Moreover, all gradations in structure between these three component elements may be observed, one area merging into another, and the histological appearances suggesting very strongly that all three elements are merely different manifestations of the same tissue.

FIG. 146.—Cellular tumour in which the cells still retain the characteristics of those of a typical mixed tumour. This is the type of growth sometimes wrongly called 'sarcomatous'. (× 340.)

Apart from the typical group, certain tumours stand out microscopically on account of their high cellular content. These highly cellular tumours are of various kinds. We have already noted, in dealing with the typical tumours, that the collections of cells may be either arranged diffusely without a definite formation, or well differentiated into structures resembling ducts and alveoli. The same applies to the highly cellular tumours. The first type to be recognized, therefore, may be regarded as a highly cellular counterpart of the tumour illustrated in *Fig.* 143. That is to say that its cells resemble

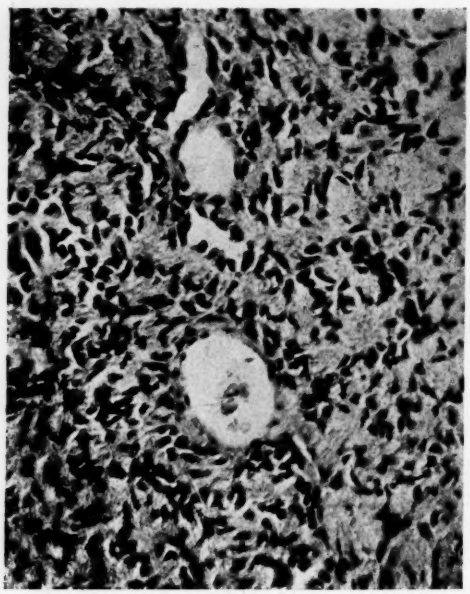

FIG. 147.—Same case as *Fig.* 146, showing immature tubule formation. (× 340.)

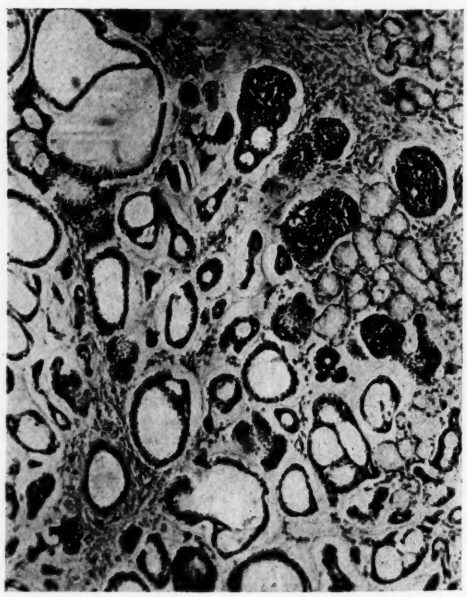

FIG. 148.—Tumour showing a marked tendency to tubule formation. (× 60.)

those of that tumour in structure, staining, and arrangement, but differ in that they are much more numerous and diffusely spread throughout the whole section. *Fig.* 146 shows a tumour of this nature. This is the appearance which has given rise to the term 'sarcomatous type' employed by some authors. But even in these tumours, areas will be found in which attempts at immature tubule formation can be seen—*Fig.* 147, for example. For purposes of classification, tumours of this group may be termed "highly cellular and not well differentiated, but cells similar in type to those of a typical tumour".

On the other hand, certain highly cellular tumours are met with in which the cells, instead of being diffuse as in the previous type, are for the most part arranged in a well-marked alveolar or ductal formation. As a rule the process of differentiation stops short at the formation of simple tubules (*Fig.* 148), often containing a colloid-like secretion; but occasionally it progresses to the degree that ducts, acini, and an immature lobular arrangement can be recognized, the appearance closely resembling that of a normal functioning gland (*Fig.* 149). This is the type of tumour that constitutes the 'adenoma' of some authors. The point it is wished to emphasize here is that this highly differentiated appearance is merely the end-result of a process which may be recognized in lesser degree in the large majority of the mixed tumours. We may classify tumours of this group as "cellular but well differentiated".

Finally, a type may be recognized in which there is a high degree of cellularity, but in which, unlike the previous two tumours, the cells have lost their resemblance to those of a

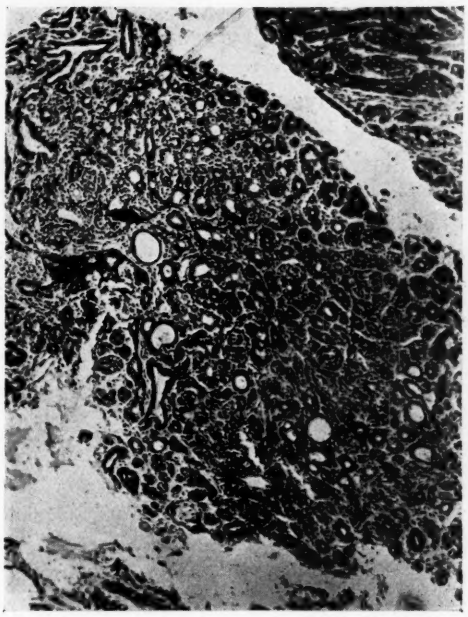

FIG. 149.—A portion of a cellular encapsulated tumour of the parotid, in which a high degree of differentiation into ducts and acini has taken place. (× 60.)

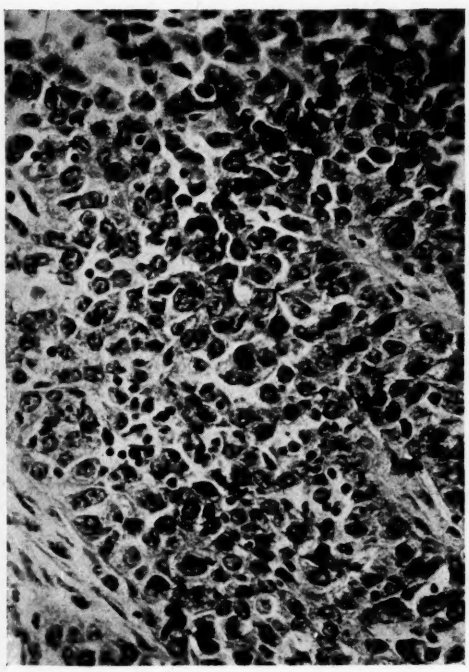

FIG. 150.—Portion of a rapidly growing cellular tumour, showing irregularity in size and shape of nuclei, and mitotic figures. (× 350.)

typical tumour, and show evidence of rapid and disorderly growth in the form of irregularity and such nuclear changes as hyperchromatism and excess of mitotic figures. Such a tumour is illustrated in *Fig.* 150. This group is almost always poorly differentiated. For purposes of classification it may be termed " highly cellular, and not well differentiated, and cells showing irregularity and the nuclear changes of rapid disorderly growth ". This group shades into that of the frank carcinomata. A consideration of where the boundary line between the two may be arbitrarily drawn will be left to a subsequent paper, but it may be here provisionally stated that, while a mixed tumour may under certain conditions infiltrate locally, it does not ordinarily metastasize, whereas the carcinomata soon tend to spread to distant parts, in the earlier stages by the lymphatics, but later by the blood-stream also.

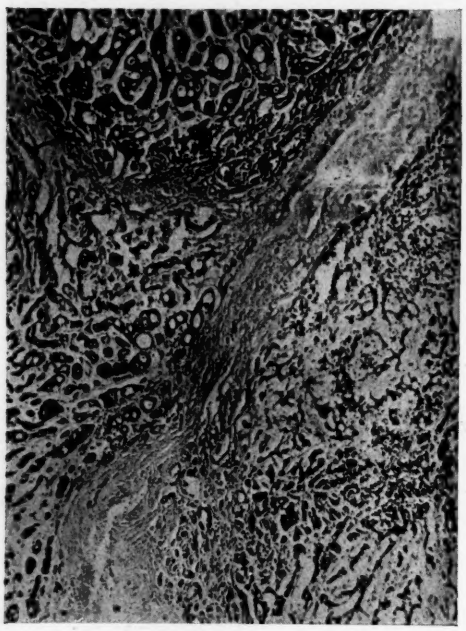

FIG. 151.—Section to show the varieties in appearance which may be met with in the same tumour. Above and to the left is a highly differentiated area; below and to the right, strands of undifferentiated cells in a myxomatous stroma; and below and to the left, an intermediate stage. (× 40.)

We thus have four groups into which the mixed tumours can be divided: (1) 'Typical' tumours; (2) Cellular, and not well differentiated, but cells similar in type to those of a typical tumour; (3) Cellular, but well differentiated; (4) Cellular, and not well differentiated, and cells showing irregularity and nuclear changes. Most tumours will fall quite readily into one or other of the above groups, but occasionally difficulty will be experienced, either because an intermediate type is met with—especially between (1) and (2)—or because of the varying appearances of different parts of the same tumour. For such cases as these the individual observer has to adopt an arbitrary standard.

The Derivation of the Mixed Tumours.—As already stated, the primary object of the present inquiry was to see whether a pathological classification could be evolved which would allow of some degree of correlation between the clinical and pathological features of the mixed tumours, and it was not proposed to enter into any prolonged discussion on the question of derivation. But, while this series of tumours was being examined and the above classification evolved, the conclusion could not be avoided that one was dealing with the different manifestations of an epithelial tumour showing varying degrees of cellularity, and in various stages of differentiation. Since it is only on such a basis that the proposed classification is a rational one, it will be convenient at this point to turn aside for a moment from more practical issues and consider briefly the evidence for the epithelial origin of these tumours. First will be given the

evidence derived from the present study, and secondly that obtained from the literature.

We have already noted that an epithelial origin is suggested by the fact that in different tumours all gradations may be observed between an undifferentiated mass of cells, and a highly differentiated tumour with ducts, acini, and an attempted lobular arrangement. Occasionally one may meet with the whole range of gradations in the same tumour. The tumour illustrated in *Fig.* 151 is an example. In the same microscopical field may be seen—above and to the left, a well-differentiated area ; below and to the right, a 'typical' tumour containing collections of cells without definite arrangement and myxomatous tissue ; and below and to the left, a stage intermediate between the two. An examination of this section left no doubt that it was the same type of cell occupying all these areas, a fact which the photograph also clearly shows. Again, in *Fig.* 152 we see a tumour the cells of which show their origin from an epithelial secreting organ in the form of a granular secretion distending them almost to bursting-point. In *Fig.* 153, on the other hand, the cells are tending to differentiate rather in the direction of squamous epithelium, and we find in one place a structure formed of a laminated keratin-like material, which bears a close resemblance to a cell-nest. The evidence of the present study, therefore, all points to the conclusion that we are dealing with an epithelial tumour.

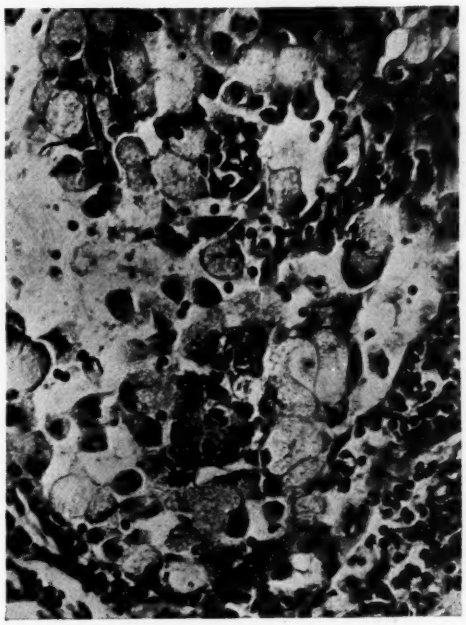

FIG. 152.—Cells from a parotid tumour distended with a granular secretion. (× 340.)

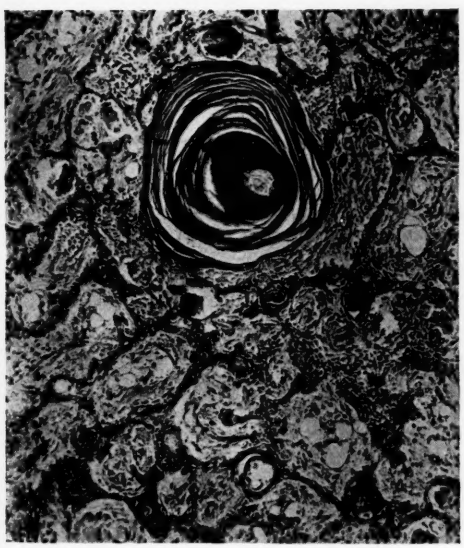

FIG. 153.—A mixed tumour showing a structure formed of laminated keratin which closely resembles a cell-nest. (× 40.)

The idea that these tumours are epithelial in origin is by no means new, and much evidence in support of the theory has been adduced in the literature. At present it claims the support of a great number of pathologists, and is being accepted as the standard teaching of an increasingly large number of surgical and

pathological text-books. The chief stumbling-block in the way of a general acceptance of the epithelial theory in the past has been the presence in many of the tumours of areas of so-called cartilage. On this question Bland-Sutton[4] has written: "A critical consideration of the histological features of the tissue called cartilage in parotid tumours convinces me that it is not entitled to this distinction"—an expression of opinion which the present study confirms. Krompecher[5] (1900) regarded the salivary growths as of purely epithelial origin with peculiar mucoid and cartilaginous metaplasia, while Ehrich[6] (1906) also demonstrated that the areas of so-called cartilage developed from the epithelial cells. In more recent times Fraser[7] (1918) by means of a cresyl-violet stain, and Fry[8] (1928) using muci-carmine, have been able to show that the cartilaginous appearance in certain areas is merely due

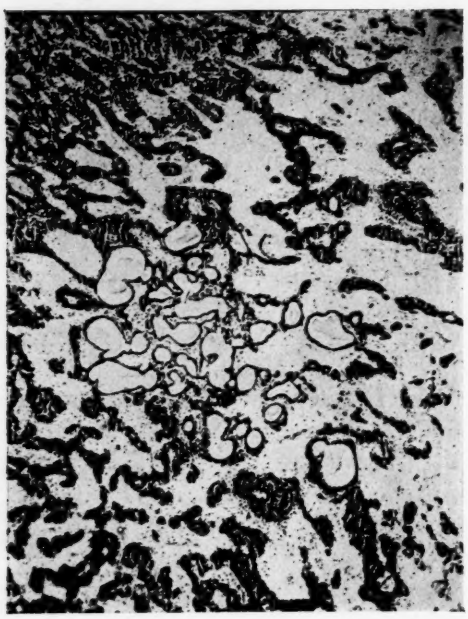

FIG. 154.—A sebaceous adenoma of the skin of the chest, showing histological features similar to those of the mixed tumours of the salivary glands. (× 40.)

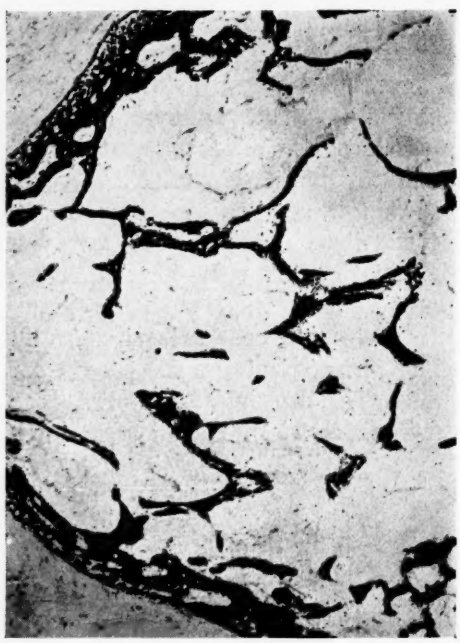

FIG. 155.—Another portion of the same tumour as seen in *Fig.* 154, showing pseudo-cartilage formation. (× 40.)

to a fibrillar condensation of the myxomatous tissue with a resulting pseudo-capsular arrangement around the cells.

In the series under consideration the presence of areas morphologically resembling cartilage has been rare. In only three cases of the series was any difficulty experienced, and the majority of areas which on superficial examination resembled cartilage were on more careful examination obviously myxomatous. Further evidence in support of the above views is furnished by the finding of similar areas in other epithelial tumours in regions remote from the salivary glands. For example, in the tumour the microscopical appearances of which are illustrated in *Figs.* 154 and 155, and which was removed from the skin of the front of the chest, certain of the cellular lobules of which

the tumour was composed microscopically showed in the centre a clear hyaline material comparable to the 'cartilage' of the mixed tumours of the salivary glands. In *Fig.* 156, which is a microphotograph of a similar tumour removed from the soft tissues of the thumb of another patient, the resemblance to cartilage is even more striking. Both these tumours were probably adenomata arising in sebaceous glands, and both were quite superficial and encapsulated. In neither, therefore, would any sequestration theory be acceptable as explaining the origin of the 'cartilage', and the simplest and most obvious explanation is that this material, whatever its nature, is derived from the epithelial cells.

A position has thus been reached at which it is necessary to accept one of two views about this so-called cartilage. Either it is not cartilage at all, but a condensation of an epithelial-derived myxomatous tissue bearing a microscopical resemblance to cartilage; or, if it is true cartilage, then it comes from the epithelium by a process of metaplasia. To accept the latter view involves a rejection of biological tenets, but on this point Ewing[9] has written: "However violently this interpretation may conflict with long-established views regarding tissue growth, it appears to be necessary to accept the facts so well attested by a close study of these tumours." Chemically there is no fundamental reason why such a change should not take place, since myxomatous tissue and cartilage are probably closely related. At any rate, it may be stated that the occasional demonstration of an area resembling cartilage is no valid objection to the epithelial nature of the mixed tumours of the salivary glands.

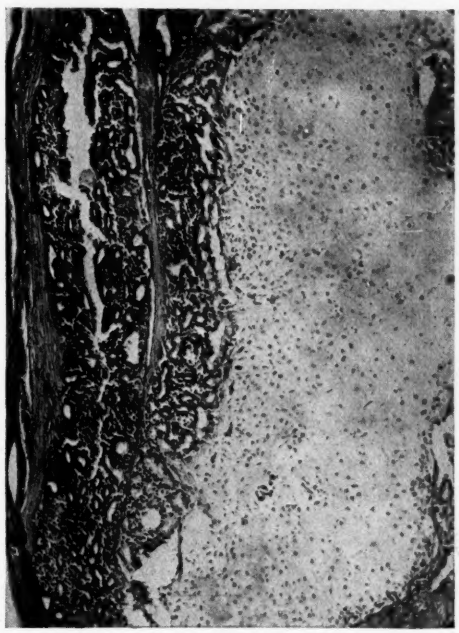

FIG. 156.—Sebaceous adenoma from the thumb with 'cartilage' formation as in the parotid.

Terminology.—If the epithelial origin of the mixed tumours is accepted, the question arises what they should be called. The term 'adenoma' might be used as denoting an innocent tumour of an epithelial secreting gland; but, in view of the rather special features of the salivary-gland tumours, it might be as well to retain the term 'mixed tumour', regarding it, however, not as referring to the derivation of the tumour, but as an expression of the varied histological appearances encountered.

II. THE CLINICAL COURSE OF THE DISEASE.

In this section the clinical features will be considered alone, without any attempt at correlation with the pathological findings, the latter task being left until the next section. In all there are 55 cases for analysis, in 52 of

which there was histological confirmation of the diagnosis; 3 cases are admitted in which no microscopical examination was made on account of their typical clinical characteristics. These 55 cases constitute all those treated at the hospital from the beginning of 1919 to the beginning of 1929. The results of the post-operative inquiry are correct to the end of July, 1929.

Region Involved. — The site of origin of the tumours was as follows :—

	CASES
Parotid	38
Submaxillary	6
Palate	5
Other regions .. .. .. (Lip, angle of mouth, face, tongue, sublingual gland.)	5
Not known	1

In agreement with general findings, the parotid is much the commonest site for the tumours, though the submaxillary and palatal glands are by no means infrequently involved. No adequate explanation has been offered to account for the special predisposition of the parotid as compared with other salivary glands. The relatively large number of cases in the palatal region is interesting. Though cases of this nature have been recorded from time to time, it is only within recent years that it has been recognized that they probably constitute the commonest encapsulated tumours of this region. The submaxillary salivary gland is involved sufficiently often to render unnecessary the undue hesitation that is still seen in making a diagnosis of mixed tumour of this region. The tongue case is worthy of note on account of its rarity. As for the tumours in the remaining regions, it will be noticed that they all tend to be grouped close to the orifice of the mouth.

Recurrence after Operation.—Dealing, as the present series does, with cases that have been treated at various times between the beginning of 1919 and the beginning of 1929, the period during which the liability to post-operative recurrence has existed varies from ten years in the earlier cases to a few months in the later. In some of the cases much more than ten years' post-operative history was available, owing to the fact that the patients had had previous operations, in one such case the first operation having taken place as long ago as 1901. Accordingly the value of the post-operative history varies for each individual case. Such general conclusions as are possible will be given and discussed, the tumours being considered under the region involved.

Parotid.—Of the 38 parotid tumours, 6 were recurrent cases when first treated at the hospital, and 5 recurred following a primary operation at the hospital, making a total of 11 recurrent cases in all. Twenty have never developed a recurrence, and are at present (July, 1929) either alive and well, or have died of some other cause without recurrence. Seven cases cannot be traced.

Of the 20 cases free from recurrence, in 2 the time period which has elapsed since operation is nine years, in 4 eight years, in 1 case seven years, in 3 cases six years, in 2 five years, in 2 four years, in 1 case three years, in 3 cases two years, and in 2 one year.

Of the 11 recurrent cases, 4 developed their recurrences within a few months to a year after operation, 3 cases within five years, 3 within ten years, and 1 case as long as nineteen years after operation.

Submaxillary.—Of the 6 submaxillary cases, 4 are known to be free from recurrence for varying periods up to seven years; 1 developed a recurrence with which he died within a year of operation, and 1 cannot be traced.

Palate.—Of the 5 palatal cases, 4 are free from recurrence, and 1 developed a local recurrence two years after operation, which is at present being investigated.

Other Regions.—The tongue case cannot be traced; the lip, angle of mouth, and face cases are alive and well, while the tumour of the sublingual was a recurrent case when first treated at the hospital, but is now alive and well.

Summarizing the question of recurrence incidence, we may say that, though a large number of cases treated by operation can survive for long periods without developing a recurrence, yet on the whole the recurrence-rate is relatively high; and since there is one case in which recurrence developed as long as nineteen years after the primary operation, there is no arbitrary time-limit that can be fixed beyond which it can be said that the liability to recurrence ceases.

Influence of Region Involved on Recurrences.—On general principles one would expect that the parotid would be more liable to recurrence than other sites, owing to the fact that operative procedures there are often restricted from fear of damaging the facial nerve, whereas in the submaxillary, palatal, and other regions there is no such anatomical deterrent. An examination of the literature reveals a certain amount of confirmation of this view. The evidence of the present study also points in the same direction, though the number of extraparotid tumours is not large enough to enable any definite conclusions to be formed. The fact, however, that recurrences other than parotid do develop proves that other factors besides ease of surgical removal must be considered in giving a prognosis. This point will be left until the next section for further elaboration.

Clinical Types of Recurrence.—If a recurrence develops, it may take one or two distinct forms. In the first place, an encapsulated tumour may be found resembling in all its clinical features the primary tumour, with the exception that surgical removal may perhaps be slightly more difficult owing to the fibrosis resulting from the previous operation; this may be termed the 'encapsulated type of recurrence'. The other form is the 'infiltrative type of recurrence'; in this type unencapsulated tumour masses may be met with infiltrating locally, spreading upwards to the temple, inwards to the mouth and behind the jaw, and downwards through the tissues of the neck. In addition, fungation through the skin may take place, but metastasis by lymph- or blood-stream does not ordinarily occur. Occasionally a mixed tumour may be incompletely encapsulated from the beginning, and it is in this type of case that cells are especially likely to be left behind at the primary operation. A typical example of local infiltrative recurrences is furnished by *Case* 43 of this series, the photographs of which patient are given in *Figs.* 157, 158. *Fig.* 159 is an illustration of a non-recurrent encapsulated case for comparison.

Case 43 was a woman who in August, 1908, when 40 years of age, first had a mixed tumour enucleated from the left parotid region. A recurrence developed, which was removed surgically in 1911, and a further recurrence was removed in 1912. In 1917 an infiltrating mass was present in the left parotid region associated with complete facial paralysis on that side, the latter probably being due to operative trauma. The burial of radium resulted in a shrivelling up of this recurrence. In 1926 further buried radium was given for an infiltrating mass projecting both

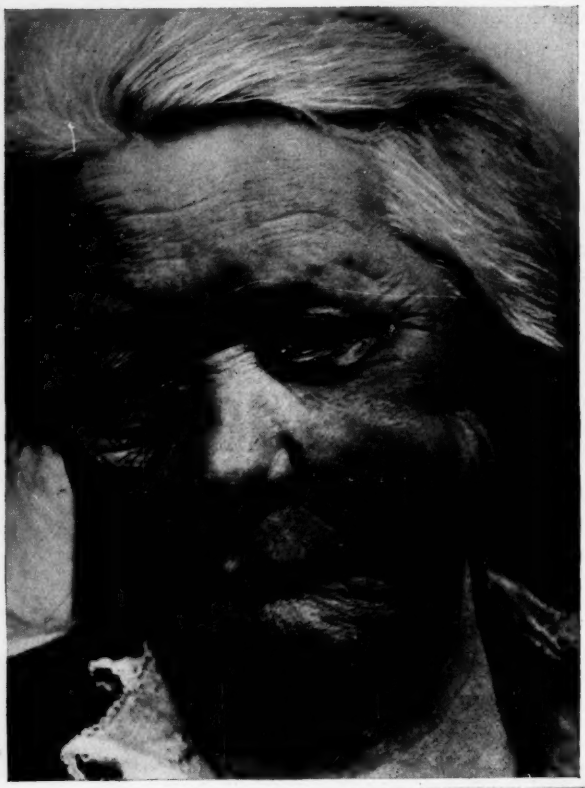

FIG. 157.—*Case* 43. Clinical photograph of an infiltrative type of recurrence. Since 1917 this patient's recurrences have been kept in check by repeated insertions of radium. No metastases have developed, and the histological appearances are still those of a typical mixed tumour. (The facial paralysis is probably traumatic.)

FIG. 158.—Same case as *Fig.* 157.

externally and into the mouth, where it was ulcerated at one point. In March, 1929, a recurrent mass was removed from the left submaxillary region, and in July, 1929, radium was inserted into a temporal recurrence. When seen a few months later she was apparently free from signs of active growth. Portions of the tumour removed microscopically in 1927 and 1929 both showed the typical structure of a mixed parotid tumour. At no time were distant metastases found.

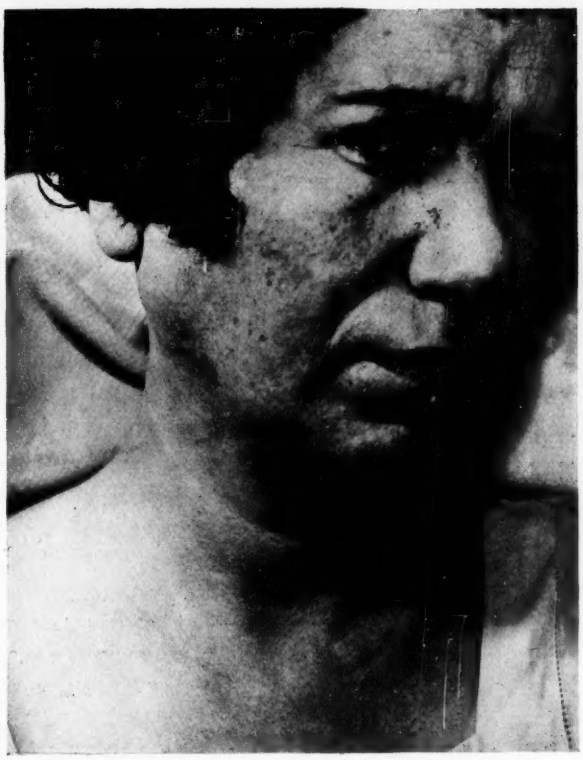

FIG. 159.—*Case* 47. Appearance of an ordinary primary mixed tumour of the parotid.

III. THE CORRELATION OF THE CLINICAL AND HISTOLOGICAL FINDINGS.

It will be remembered that on a histological basis the mixed tumours were divided into four groups: (1) Typical tumours; (2) Cellular, and not well differentiated, but cells similar in type to those of a typical tumour; (3) Cellular, but well differentiated; (4) Cellular, and not well differentiated, and cells showing irregularity and nuclear changes. We will now consider the clinical results in the different histological groups.

1. *Typical Tumours.*—Twenty-nine cases of the series fell into this group. Of these, 18 were free from recurrence, 4 were recurrent cases, and 7 could not be traced. These figures will serve as a standard with which the other groups may be compared.

2. *Cellular and Not Well Differentiated, but Cells Similar in Type to those of a Typical Tumour.*—Nine cases were classified as belonging to this group, of which 8 were free from recurrence at the time of investigation, and 1 was

a recurrent case. This gives a recurrence-rate rather less than that of the typical tumours, though this is a point on which stress cannot be laid owing to the smallness of the figures. It does, however, prove that a high degree of cellularity is no indication of an especial liability to recurrence, provided that the cells maintain the same characteristics as those of a typical tumour. This is an important conclusion since the contrary has often been stated; apart from other considerations, it prohibits this group from being included in the 'cellular and sarcomatous type' of some classifications, as this term by itself implies a special liability to recurrence.

3. *Cellular, but Well Differentiated.*—Six cases fell into this group, of which 1 is free from recurrence, 3 are recurrent cases, and 2 cannot be traced, so that of the 4 cases in which the result is known, 3 have recurred. It must be admitted that the group is so small that any accurate statistical conclusions are impossible; but even so, when one considers that on theoretical grounds it would be expected that a high degree of differentiation would indicate, if anything, a lesser liability to recurrence, the recurrence-rate must be regarded as surprisingly high. Further discussion of this question will be reserved for a subsequent paragraph.

4. *Cellular, and Not Well Differentiated, and Cells Showing Irregularity and Nuclear Changes.*—Eight cases were in this group, of which 2 are free from recurrence, 5 are recurrent cases, and 1 cannot be traced. From this one may conclude that tumours of a high degree of cellularity, with the histological signs of rapid irregular growth, show a special liability to recurrence.

So far, then, our investigations have shown that recurrence may occur in all histological types of mixed tumour, that a high degree of cellularity of itself does not indicate a special liability to recurrence, but that certain types of highly cellular tumour seem to be associated with a tendency to recurrence.

The Causes of Recurrence.—Leaving aside the question of blood and lymph metastasis, which has not occurred in the tumours of the present series, the term 'recurrence' is used clinically to denote the fact that somewhere in the region of the primary operation a second somewhat similar type of tumour has developed. From the strictly pathological standpoint the term would imply that a cell or cells of the original tumour were left behind at the first operation, and that after a greater or lesser interval of dormancy they had taken on active growth, and developed into a second tumour. While this pathological process probably accounts for the majority of cases, it is worthy of note that, as pointed out by Ehrich, there are two other important causes of clinical recurrence of the mixed tumours, examples of both of which may be found in the present series.

In the first place, the tumours may be multiple at the time of the primary operation, one being large and obvious, and the other a small impalpable or microscopic seedling. If the large tumour only is removed, the seedling tumour remaining may continue to increase in size, and when sufficiently large and superficial constitute what is clinically a 'recurrence', but pathologically merely the normal continued development of a second tumour. It is of course impossible to determine in what percentage of 'recurrences' this

takes place, but one is able to infer the existence of the phenomenon from the fact that occasionally a tumour is removed, and attached to it is found a small seedling nodule, which constitutes quite a separate entity the existence of which was previously unsuspected. Two such cases were met with in the present study. The first is illustrated in *Fig.* 160, which shows the edge of a small spherical tumour, completely encapsulated and separated by loose connective tissue from the large tumour with which it happened to be removed. The second example is seen in *Fig.* 161. Here the main tumour is completely encapsulated, and in the capsule in one instance, and attached to the outer side in the other two, are three quite separate seedling tumours.

FIG. 160.—Portion of a typical encapsulated mixed tumour which was removed as a small seedling nodule attached to a larger tumour. (× 40.)

The other cause of clinical recurrence is merely the development at a later date in the same gland of another tumour of similar nature. In other words, the 'recurrence' represents the tendency of the salivary gland to develop tumours. For example, in the type of case illustrated by *Case* 6 of this series it is difficult to believe that an easily enucleable 'recurrence' which did not appear until ten years after the first operation should be due to cells left behind on that occasion, when the primary operation was also a simple enucleation. But in one case of the series it is possible to affirm quite positively that the 'recurrence' was not due to residual cells of the original tumour, because it developed on the opposite side. This is *Case* 14, which is that of a woman, age 31, who, two years after the enucleation of a tumour of the right parotid region, developed a 'recurrence' not only on the side of the operation, but also on the opposite previously unaffected side. Two and a half years after the second operation she was well and apparently free from growth. The microscopical appearances of the primary and both 'recurrent' tumours were identical.

FIG. 161.—To show mixed tumour from the parotid, with three seedling nodules in, and attached to, the outer aspect of the capsule of the main tumour. Hæmorrhage has occurred into the latter.

The present series therefore affords evidence pointing to the existence of two types of clinical recurrence which are not examples of true pathological recurrence of the original tumour: (1) Recurrence due to the continued development of unsuspected seedling nodules, present but not detected at the primary operation; (2) Recurrence due to the appearance of a fresh tumour in a gland which shows a tendency to tumour development. By an appreciation of these facts, the position of at any rate some of the salivary-gland tumours becomes comparable with that of the adenomata of the thyroid gland, in which similar causes of clinical recurrence operate.

It will be convenient at this point to refer to the fact previously noted in this paper that, judged by the small number of cases available for study in the present series, highly differentiated tumours recur with surprising frequency. In the case last quoted, in which the tendency to tumour formation in the salivary glands was so marked that 'recurrence' occurred bilaterally, a very high degree of differentiation into ducts and alveoli was shown by all the tumours (*see Fig.* 149). This case suggests the possibility that the explanation of the frequency of recurrence of the highly differentiated tumours lies in the fact that glands which have the tendency to the repeated development of tumour formations show also a special liability to tumours of this type. In other words, a high degree of differentiation and the tendency to multiple tumour formation run parallel, and thus the apparent recurrences are not true pathological recurrences at all. This suggestion will obviously require further confirmation before it can be accepted as a fact, but it seems worthy of consideration.

FIG. 162.—Section of an unencapsulated recurrence of a mixed tumour infiltrating beneath the skin. (× 40.)

Type of Recurrence and its Bearing on the Clinical Course.—It has been noted earlier that recurrences may be divided into two categories clinically, the 'encapsulated' and the 'infiltrative'. Histologically also the two types are quite distinct, the former showing the presence of a fibrous capsule as in the original tumour, while in the latter cell masses are found infiltrating the surrounding tissues (*Fig.* 162).

In the present series, of the 11 cases of recurrence in which sufficient information is available to enable a classification to be made, 4 were of the 'encapsulated' and 7 of the 'infiltrative' type. The prognosis of the two types is very different. The encapsulated recurrence may be enucleated in similar fashion to the original tumour, and the prognosis following its removal appears to be no worse than that of a primary operation. Thus *Case* 6 remains

quite well nine years after an operation on a recurrence of this type. The infiltrating tumour, on the other hand, is much more difficult to eradicate and the prognosis is correspondingly worse. Numerous and repeated operations are often required, as in *Case* 32 of the present series, in which five operations were performed between the years 1912, when the original tumour of the left parotid was removed, and 1928, the final operation being a wide excision of a locally infiltrating mass of growth; microscopical sections of the latter still showed the structure of a simple parotid tumour. It is in this type of case that radium is sometimes so valuable (*see Case* 43 already quoted, p. 251).

The Relation between the Microscopical Appearances of the Primary Tumour and the Recurrent Tumours. — The statement is sometimes made that successive recurrences present more and more irregular histological features, until eventually a frank carcinoma results. The material of the present investigation was therefore examined from this point of view. Of the total 14 recurrent cases, in eight no information is available bearing on the question. In two cases the recurrence was similar in microscopical appearance to the primary tumour. In one case, though the section of the primary tumour was not available, a recurrence removed in 1929 was identical with one removed in 1927. In the remaining two cases the sections of the primary tumours were not available, but the reports stated that they were typical mixed tumours: this was the group into which the recurrences also were independently placed after examination. As far as the present investigation goes, therefore, there is no evidence of change of histological type in recurrences.

TREATMENT.

Such observations on treatment as were suggested by the present study may perhaps be briefly given. To deal first with the primary tumours, it is obvious that in situations such as the submaxillary, where a wide excision is possible, such a procedure should be associated with a lesser liability to recurrence than a simple enucleation. In the parotid, however, where the majority of these tumours occur, enucleation must continue to be the surgical method most often indicated, owing to the danger in more radical measures of severing the facial nerve and other important structures. In order to kill any cells inadvertently left behind or any seedling nodules present, the insertion of radium either into or surrounding the tumour cavity seems a wise and rational procedure. This was done in some cases of the present series, but not sufficiently often to enable a statistical evaluation to be made.

The question arises whether radium should replace surgical removal in certain of these cases. There is no information bearing on this question in the present investigation. In the literature, Sistrunk[10] has stated that the experience of the Mayo Clinic has been that radium is not as satisfactory as surgery in this class of tumour. On the other hand, Bland-Sutton has noted that radium sometimes exerts a beneficial influence on the mixed tumours, while the manner in which some of the recurrent tumours of the present series have responded to radium has been very striking. Quick[11] has pointed out that all types of mixed tumour do not respond equally well to radium, the more cellular varieties giving the best results, while the acellular myxomatous

growths are rather resistant. For this reason he recommends a preliminary biopsy. At present, therefore, a combination of surgery and radium would appear to offer the best prospect of maximum benefit to the patient, in that it provides the advantages of both forms of treatment.

As for the treatment of recurrences, in the encapsulated type measures similar to those employed for a primary tumour are indicated. In the infiltrative type, while surgical excision is sometimes possible, in view of the extensive procedures often necessary and the resulting deformity, radium therapy would seem to be preferable. In addition, radium is able to afford benefit to cases outside the scope of surgery.

CONCLUSION.

As a result of the present study the conclusion has been reached that the mixed tumours of the salivary glands are a composite group of epithelial tumours, the varying pathological features of which depend on the degree of differentiation attained, the rapidity of division of the cells, and the amount of myxomatous change undergone by the epithelium. According to the degree to which these changes have taken place, all gradations may be encountered between a myxoma on the one hand and a highly differentiated tumour with ducts and acini on the other, and between a slowly growing tumour with regular cells and an irregular anaplastic growth. Based on these factors, a practical pathological classification has been evolved. The combined pathological and clinical study has shown that this classification allows of a certain amount of correlation between the clinical and pathological findings, but that the correlation is by no means complete.

This investigation was carried on while working in the Bland-Sutton Institute of Pathology, Middlesex Hospital, under a grant from the British Empire Cancer Campaign, and is part of an Essay which was awarded the Jacksonian Prize of the Royal College of Surgeons of England for the year 1929. I wish to thank Professor James McIntosh, Director of the Bland-Sutton Institute of Pathology, for allowing me to use the material and the records of the Institute, and for his constant kind interest and help, the Surgeons of the Middlesex Hospital for permission to use their cases, and the Council of the Royal College of Surgeons of England for permission to publish the work.

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STUDIES IN EXPERIMENTAL MITRAL OBSTRUCTION IN RELATION TO THE SURGICAL TREATMENT OF MITRAL STENOSIS.*

By W. C. WILSON, Edinburgh.

Twenty-eight years ago Sir Lauder Brunton,[7] impressed by the hopelessness of finding a remedy in medicine for the condition of stenosis of the mitral valve, ventured to suggest that relief might some day be available in this distressing malady from surgical measures. Brunton's proposal, while naturally provoking considerable opposition and adverse criticism, stimulated such interest and effort in the field of cardiac surgery that the procedure he suggested was eventually carried out some twenty years later in operations on human beings. During the past eight years considerable energy, study, and care have been devoted to the development of the operative treatment of mitral stenosis, more especially by Cutler and his co-workers in America. When the situation at the present time is reviewed, it may be said that the position of the physician confronted with this form of cardiac disease is but little more advantageous than it was in Brunton's day. Unfortunately, however, surgery cannot yet offer sure and certain alleviation, and the problem of operative relief is still one of great difficulty. In this paper some aspects of the problem are considered, and an experimental investigation is recorded which, though incomplete, may, it is hoped, be of interest to other workers in this new surgical field.

It is not intended to enter here into a full discussion of mitral stenosis, or to review the history of the development of its operative treatment. A full account of the subject is given in the publications of Cutler and his associates,[4, 5, 9–14] to which reference should be made. We shall be content to consider shortly the operations already performed, their results, and the grounds upon which they are based.

Operation for mitral stenosis has been carried out on 10 patients: by Cutler in 7 cases,[9, 13, 14] and by Allen,[2] Souttar,[28] and Pribram[26] in one case each. Cutler's first case lived for four and a half years. Souttar's patient is still alive five years after operation, and the remainder died. In one case[2] the operation was not completed, and in the others death occurred at short intervals after operation. The results of operation are scarcely encouraging. A common experience in all pioneer work in surgery has been initial disappointment, and this new branch has proved no exception.

On what grounds is the operative treatment based? The aim in all cases has been to widen the constricted orifice of the mitral valve and so

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allow a greater volume of blood to pass from left auricle to left ventricle. The condition of stenosis is thus converted into one of incompetence. There is, of course, no question of restoring the normal condition of the valve. Clinical study gives strong support to the view, which is widely held, that mitral incompetence is a less serious valvular lesion than mitral stenosis. At the present time there seems almost entire unanimity among cardiologists that myocardial damage plays the primary rôle and valvular lesions only a secondary part in cardiac disease. There can, however, be little doubt that in some cases the mechanical obstruction to the circulation in severe mitral stenosis must impose a serious burden on a myocardium already damaged. Advocates of operation argue further that benefit will follow if the valvular lesion of stenosis is changed to incompetence, in which the mechanical embarrassment is not so great. Experimental evidence,[1, 9, 17] which suggests that stenosis at the mitral valve causes more serious interference with cardiac function than incompetence, has also been cited in favour of operation. The experiments, however, were of the 'acute' type, and the evidence does not seem admissible.

We have conclusive proof that incompetence of the mitral valve can be produced in healthy animals with safety,[1, 9] and the pioneer work on human cases has demonstrated beyond any doubt that the diseased heart can withstand operative trauma. There is, however, no proof that an operation which changes a long-standing mitral stenosis suddenly to mitral incompetence can readily be tolerated, nor that the change will be beneficial. Such proof is lacking because it has not yet been possible to produce mitral stenosis in animals. Even if the proof were forthcoming, there is still little to guide the surgeon in determining what degree of incompetence he should create. Therefore the primary aim of this investigation was to produce in animals an obstructive condition at the mitral valve resembling mitral stenosis in human beings, to study the effects of the obstruction on the circulation, and later to produce, and observe the results of, a change to incompetence.

EXPERIMENTAL MITRAL OBSTRUCTION.

Attempts to create mitral stenosis in animals have met with little success. Endocarditis produced by micro-organisms usually gave rise to incompetence of the valves.[27] Mechanical narrowing of the auriculo-ventricular ring and excision of portions of the left ventricle caused no permanent obstruction, and the introduction of radium around the valve to produce fibrosis was not attended with any degree of certainty.[9] The most valuable work reported in this field is that of Powers,[25] who injected streptococci into the bloodstream after he had damaged the mitral valve by electrocoagulation. Vegetative endocarditis resulted, and was followed some months later by stenosis of the orifice and thickening of the valve leaflets. The mortality from operation and from subsequent endocarditis was considerable. We have not had the opportunity of employing this method.

Production of Obstruction. — To produce obstruction at the mitral valve we first tested methods previously employed by others.[6, 8] The methods proved difficult and uncertain in results. It was then decided to create an

obstruction to the circulation by inserting and fixing in the heart cavity, across the left auriculo-ventricular ring, a diaphragm of tissue which contained a small central opening. The tissue selected was parietal pericardium, which has a serous covering on both inner and outer aspects. The operation was performed successfully on several occasions, and it was demonstrated that pieces of pericardium could be inserted into the heart cavity without causing clotting. As a method of producing mitral obstruction it possessed several disadvantages. The procedure proved somewhat difficult and time-consuming, and it involved the sacrifice of a considerable portion of auricular appendage, through which we hoped to introduce an instrument in a subsequent operation.

The method of producing mitral obstruction finally adopted will now be described in detail. The greater part of the anterior and left portion of the parietal pericardium was removed and cut into two or more strips of a length greater than the antero-posterior diameter of the left ventricle at the level of the auriculo-ventricular junction. The strips were rolled up to form long solid cords, and to each end of the strip a suture of linen thread was attached. One suture was threaded on a straight round-bodied needle, and the needle and suture were passed through the ventricle from behind forwards. To do this the heart was rotated gently to the right by a silk suture inserted near the apex, and the needle entered at a point about 0·5 to 1 cm. to the left of the posterior interventricular sulcus and immediately below the level of the auriculo-ventricular sulcus, and was made to emerge anteriorly, at the same level, in the angle between the anterior longitudinal sulcus and the auriculo-ventricular sulcus. By pulling on the suture the pericardial strip was drawn across the heart cavity until its anterior end projected through the anterior wall of the ventricle. The ends of the strip remained outside the heart wall and effectively plugged the openings. A second, and if necessary a third, strip was inserted across the cavity on the left of the first at intervals of 2 to 3 mm. The strips were kept gently on the stretch while the ends were stitched to the heart wall. Care was taken in inserting the strips to avoid injury to, or pressure on, the main coronary vessels, and in fixing the strips to avoid any constriction of vessels or heart muscle.

When the operation was successfully performed the strips of pericardium lay across the mitral orifice, thereby narrowing it, and, as they passed through one or both cusps, they tended to fix and immobilize them, thus preventing full closure as well as full opening of the valve. In short, they produced a condition of mitral obstruction to which was added a slight degree of mitral incompetence, thus simulating the condition of mitral stenosis usually found in human beings.

Results of Transplanting Tissue into the Heart Cavity. — Fascia lata transplanted into the heart cavity produces massive clotting which causes death in from three to eighteen days, either by blocking the mitral orifice compietely or by embolism. In one experiment, tendon with a synovial covering was employed. No clotting occurred. Parietal pericardium was most readily available, and proved entirely suitable to the purpose. Transplanted strips were examined at intervals of from three days to fourteen months later. There was no obvious change in the appearance of the strip, beyond some

patchy red staining, until about two weeks after transplantation; then its surface appeared smoother and more regular and its consistence was definitely tougher and firmer than previously. From then to about four months after transplantation the strip gradually acquired a smooth, rounded, and usually perfectly regular outline, and a tough inelastic consistence. No changes occurred subsequently. Occasionally smooth rounded nodules were found at the point where the strip pierced the valve cusps. These were formed from small collections of fibrin which became organized after the first week, and were found on the cusp as well as on the strip. Smooth nodular thickenings of the cusps were not infrequent at areas where the valve in its movements impinged on the strip.

Microscopic examination revealed that the strip became gradually compressed into a solid cellular cord with a covering of smooth endothelial-like cells. In some places minute quantities of fibrin were deposited which contained red cells in the meshes. The fibrin ultimately became organized and the area surrounded by an endothelial-like lining. A surprising feature was the presence of well-formed blood-vessels which traversed the strip in the direction of its longitudinal axis.

Effects of Experimental Mitral Obstruction. — In order to estimate the effects of mitral obstruction the following tests were employed: (1) Measurement of the volume of blood passing through the lungs in unit time, calculated according to the principle of Fick[18]: this is expressed here as the cardiac output per minute; (2) Electrocardiographic records; (3) Measurement of the heart shadow shown by X rays.

1. *Measurement of the Volume of Blood Passing through the Lungs.*—In the first test the oxygen intake per minute and the oxygen content of the mixed venous blood and of the arterial blood were found. The oxygen intake per minute was divided by the difference in oxygen content of the mixed venous blood and arterial blood, and the result gave the volume of blood passing through the lungs in unit time.

In these experiments the animals were anæsthetized by amytal and morphine in order to prevent struggling or excitement, and the experiments were conducted under exactly the same conditions on each occasion. The anæsthetic dose was 0·35 c.c. of the amytal solution and 3 mgrm. of morphine per kilo. of body weight. Depression of respiration or circulation was not marked. A sample of mixed venous blood was obtained by puncture of the right ventricle, and one of arterial blood from the femoral artery. The samples were drawn under paraffin and oxalated. The oxygen content of the blood samples was estimated in a Haldane's blood-gas apparatus.[19] Simultaneously the air expired by the animal was collected in a modified Douglas bag over a period of ten minutes, its volume measured in a wet gas meter, and a sample analysed in a small Haldane's air-analysis apparatus.[20] The oxygen taken up by the animal per minute could then be ascertained. All the data necessary for the final calculation were then available.

Table I shows the results of estimation of cardiac output per minute in normal dogs. The experiments were repeated in each animal on three occasions.

2. *Electrocardiographic Records.*—Records vary greatly with change in position, and it is essential to place the animal in exactly the same position at each examination. In these experiments the animal lay on its back in a special box which prevented any movement or tilting.

3. *X-ray Photographs of the Heart Shadow.*—Photographs were taken on each occasion under identical conditions.

RESULTS.—Experimental mitral obstruction produced by pericardial strips was carried out in 12 animals, 1 cat and 11 dogs. The cat was killed four months after the procedure and a considerable degree of obstruction was

Table I.—CARDIAC OUTPUT IN NORMAL DOGS.

DOG NO.	WEIGHT	OXYGEN INTAKE PER MINUTE	A–V OXYGEN DIFFERENCE	CARDIAC OUTPUT PER MINUTE	OUTPUT PER KILO.	NOTES
	Kilo	c.c.	Vols. per cent	c.c.	c.c.	
9	12·0	59·98	4·30	1395	116	
15	8·6	54·67	5·61	974	113	
30	17·0	80·00	4·10	1951	115	
31	20·0	150·00	5·00	3000	150	Whippet
34	23·0	80·61	4·00	2015	88	
35	6·0	41·18	4·20	980	163	Young dog
36	8·2	32·40	3·30	982	120	
37	13·8	76·04	4·00	1901	138	Young dog
38	19·2	62·79	4·10	1531	80	Heavy old dog

Table II.—CHANGES AFTER MITRAL OBSTRUCTION.

DOG NO.	TIME AFTER OBSTRUCTION	CHANGES IN HEART SOUNDS	ELECTROCARDIOGRAPHIC CHANGES	X-RAY	REDUCTION IN CARDIAC OUTPUT
					Per cent
30	2 months	Roughened first sound	Ventricular extrasystoles. Inversion of T in all Leads	No change	32
31	3 months	Faint mitral systolic murmur	No change	No change	22
35	5 weeks	Faint mitral presystolic and systolic murmurs	Slight reduplication of P wave	No change	25
36	2 months	Roughened first sound	Inversion of T in all Leads (previously in Leads II and III) ..	No change	24

Table III.—CARDIAC OUTPUT BEFORE AND AFTER MITRAL OBSTRUCTION.

DOG NO.	TIME AFTER OBSTRUCTION	OXYGEN INTAKE PER MINUTE		ARTERIAL OXYGEN				MIXED VENOUS OXYGEN				A–V OXYGEN DIFFERENCE IN VOLS. PER CENT		CARDIAC OUTPUT PER MINUTE	
				Volumes per Cent		Saturation per Cent		Volumes per Cent		Saturation per Cent					
		Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
		c.c.	c.c.											c.c.	c.c.
30	2 mths.	80·00	70·00	15·0	14·2	93	90	10·9	9·2	68	58	4·1	5·0	1951	1400
31	3 mths.	150·00	142·00	15·5	15·0	94	90	10·5	8·9	64	53	5·0	6·1	3000	2328
35	5 wks.	41·18	41·64	14·2	9·9	90	87	10·0	4·2	64	35	4·2	5·7	980	730
36	2 mths.	32·40	33·75	12·0	12·0	92	88	8·7	7·5	67	58	3·3	4·5	982	750

found (*Fig.* 163). In the first three dogs of the series the tests revealed no deviation from the normal. The animals remained in good condition. A roughening of the first heart sound was noted in two, while in the third a faint presystolic and a systolic murmur were audible over the apical region. The animals were killed at intervals of from seven to ten months after operation. In the first two the obstruction was slight in degree and probably did not interfere with the function of the heart. In the third a definite obstruction was present (*Fig.* 164) and a slight degree of hypertrophy of the right ventricle was noted.

FIG. 163.—*Cat.* Four months after operation.

FIG. 164.—*Dog* 17. Seven months after operation.

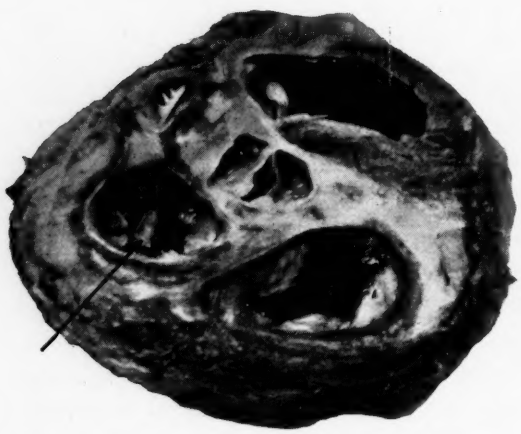

FIG. 165.—*Dog* 34. Two months after operation.

FIG. 166.—*Dog* 37. Two months after operation.

FIGS. 163–166.—EXPERIMENTAL MITRAL OBSTRUCTION.
(Arrows indicate obstructing pericardial strips.)

A more marked obstruction was created in the remaining eight dogs of the series. One died twenty-four hours after operation, apparently from the severity of the obstruction, and one died six days later from hæmorrhage due to an error in technique. The remainder recovered. Unfortunately two died suddenly during cardiac puncture two months after obstruction. In both a well-marked obstruction was present (*Figs.* 165, 166). The changes after obstruction in the remaining four animals are shown in *Table II*, and

details of the estimation of cardiac output before and after obstruction in *Table III.* As control experiments tests were carried out at intervals after an operation for removing a portion of pericardium. No definite deviation from the normal was demonstrated by the tests.

Examination of the results shows that the cardiac output was reduced in the four animals by 32, 22, 25, and 24 per cent respectively. The oxygen saturation of the arterial blood did not fall appreciably. Dautrebande, Fetter, and Meakins[15] found that there was a definite reduction in the cardiac minute volume under resting conditions in cases of mitral stenosis with even mild dyspnœa on exertion. They also found that the oxygen saturation of the arterial blood remained within normal limits when no pulmonary complications were present. In these respects, therefore, the experimental findings conformed to those in human cases of mitral stenosis. The oxygen intake remained unaltered after mitral obstruction, the oxygen content of the mixed venous blood fell, and the arterial–venous oxygen difference rose.

Electrocardiographic changes were not constant. In *Dog* 30 they were marked. Ventricular extrasystoles and inversion of the T wave in all leads appeared after three weeks and remained. These changes occurring in human beings are usually considered indicative of myocardial impairment. The dog was considerably older than the majority of the animals used. Reduplication of the P wave is a common finding in cases of mitral stenosis. A slight degree of this change was observed in the record of *Dog* 35. In *Dog* 36 the electrocardiogram before obstruction showed inversion of the T wave in Leads II and III, and after obstruction in all leads. In no case was there any sign of right ventricular preponderance.

X-ray photographs demonstrated no definite change in size or shape of the heart shadow after obstruction. The operative procedure was tolerated well in almost all cases, and the animals betrayed no obvious signs of heart failure. The response to ordinary exercise was not altered. Examination of the hearts of the animals after death left no doubt that in all cases a definite obstruction had been created at the mitral orifice, which must have impeded the flow of blood from left auricle to left ventricle. Nevertheless no marked dilatation or hypertrophy of any of the heart chambers was present.

The following conclusions can be drawn from the results. A mechanical obstruction was produced to the blood-flow at the mitral valve in all cases. The obstruction was rarely initially formidable, but was progressive to some extent for a period of probably three or four months. The cardiac output under resting conditions was thereby reduced by between 22 and 32 per cent, and its estimation was a valuable test of function. No marked dilatation or hypertrophy of the left auricle or right ventricle resulted, and therefore there were no signs of right ventricular preponderance in the electrocardiogram or change in the X-ray picture of the heart shadow. Other changes in the electrocardiogram were inconstant. Overt signs of heart failure were not observed. It is conceivable that hypertrophy of the right ventricle might have developed had it been possible to give the animals regular strenuous exercise.

RELIEF OF OBSTRUCTION.

For the relief of mitral stenosis two different surgical measures have been advocated. The first, originally proposed by Brunton and later carried out in operations on human beings, consists in widening the stenosed mitral orifice. Jarotsky,[23] of Moscow, suggested another method which, he claimed, would afford relief and would be less difficult of execution than an attack on the valve—namely, to produce an opening in the septum between the auricles. His claim that the formation of an interauricular communication would alleviate the symptoms of mitral stenosis is based on the clinical course of two cases cited by Lutembacher.[24] In these cases there was the rare association of mitral stenosis with an interauricular communication ; the symptoms of heart failure did not appear until an advanced age and were mild in degree, and life was prolonged until the ages of 74 and 61 years respectively. Both authors explained the unusually favourable course of the cases of mitral stenosis on the assumption that the abnormal communication allowed blood to flow from left auricle to right auricle, and thus the pulmonary circulation was relieved of part of its burden of stasis, which was transmitted to the great veins in the systemic circulation.

It is well, however, to note that in three other cases quoted by Lutembacher where the same anomalies were present, death occurred at the ages of 26, 29, and 41 years respectively. Moreover, there seems some justification for Lutembacher's belief that in all cases the mitral stenosis as well as the abnormal communication was of congenital origin, and adaptive processes were thus in play from the beginning of life. It is difficult to agree with Jarotsky's proposal to form an interauricular fistula for the relief of acquired mitral stenosis. The studies of Holman and Beck[21, 22] indicate that by this procedure a considerable portion of the blood volume would be short-circuited through the system composed of the auricles, right ventricle, and lungs. To impose this extra burden suddenly on a right ventricle already severely taxed would probably prove far from beneficial. Theoretically there is more justification for producing an interventricular fistula, when the dilated and hypertrophied right ventricle might obtain relief by delivering some of its blood to the left ventricle. The presence of both an interauricular and interventricular fistula would give still more favourable circumstances if the direction of the blood-flow were from left auricle to right auricle and from right ventricle to left ventricle. The volume of blood in the systemic circulation would then be augmented by a mixture of venous and arterial blood. From a practical point of view, however, an attack on the interventricular septum is precluded by the danger of damage to the conducting system of the heart.

Jarotsky's suggestion has been followed in the experimental work of Dmitrieff,[16] conducted mainly in rabbits. In one experiment in our series a fistula was made in the interauricular septum. Mitral obstruction had been created three months before. The opening was made in the septum by a finger invaginating the left auricle appendage, and was large enough to admit the forefinger. The operation was tolerated well. No changes were noted subsequently in the electrocardiogram nor any alteration of the heart shadow.

The animal remained in good condition and was killed seven months later. Examination of the heart revealed a moderate degree of mitral obstruction, and a tiny circular aperture in the interauricular septum with a diameter of about a millimetre. The fistulous opening, probably of a slit-like nature initially, had practically closed. To produce a communication in the septum in a case of mitral stenosis it would be necessary to excise and remove a piece of septum. The experiment yields no evidence in regard to the value of an interauricular communication in mitral stenosis.

Widening the Orifice of the Mitral Valve. — When the procedure of widening the stenosed orifice is considered, the problems are found to be largely technical. Some controversy has arisen concerning especially the route of approach to the valve and the method of relieving the constriction.

Method of Approach.—The valve has been approached from above through the left auricular appendage and from below through the left ventricle. The former approach is favoured by Allen and Graham[1-3] on the grounds that serious irregularities and disturbances of heart action follow the introduction of an instrument through the ventricle, while, as they point out, the left auricular appendage can be clamped, cut, sutured, or even excised without any apparent detriment to the function of the heart. This approach was employed by Souttar in his operation. Cutler at one time upheld the approach through the ventricle, which is much more accessible than the auricle, denied the occurrence of frequent serious irregularities from interference with the ventricle, and stressed the ease by which hæmorrhage from the ventricle can be controlled. His experience of operations on mitral stenosis, where he could view the thin-walled, greatly dilated left auricle, convinced him that an approach from above could not be a sound surgical measure. Recently he has modified his views, and now looks with more favour on an approach from above.

It may be noted that the irregularities of heart action observed by Allen and Graham in animals followed attempts to introduce their cardioscope through the ventricle, and to tie it in. It is not surprising that accidents occurred in these circumstances. If Cutler's technique and valvulotome are used, serious irregularities of action are comparatively infrequent. There is no doubt also that in human beings the auricle lies far back in the thorax and is much more inaccessible than the ventricle, and Cutler considers that consequently it is necessary to use a curved instrument when approaching from the auricular appendage.

On the whole, our preference is for the approach through the auricular appendage. In a large number of experiments in this investigation the appendage was clamped, incised, and used for the introduction of some instrument, and no serious accident could be attributed to interference with the appendage. In addition, it seems likely that in operations on mitral stenosis the difficulties of locating the valve will be considerably less than when the approach is through the ventricle. The instrument introduced from above will be guided by the shape of the cavity to the constricted orifice, more especially when the valve is of the funnel-shaped or 'fish-mouth' type. One further possible advantage of approaching from above

is that the instrument can be introduced through a sheath tied into the appendage. To tie a sheath into the ventricle would prove dangerous and difficult.

Relief of Constriction.—Different methods suggested for the relief of the constriction are: (1) Section of the valve; (2) Excision and removal of a piece of valve; and (3) Dilatation of the orifice. There is little to recommend section or simple incision of the constriction. It seems unlikely to confer any great benefit in widening the orifice, especially when the valve is tough, rigid, and possibly cartilaginous, and to cut such a valve with a thin-bladed knife might prove extremely difficult, if not impossible. Souttar dilated the constriction with his finger. The stenosis in his case was not, apparently, of an extreme degree. Treatment by dilatation of pathological stricture in other parts of the body must be intermittent and repeated in order to achieve success, and the same is probably true for stricture of the mitral valve. Repeated instrumental dilatation of the mitral valve does not appear as yet to be feasible. For the moment the most reasonable method seems to be excision and removal from the heart of a piece of the mitral valve. Further information on this point may be forthcoming if mitral stenosis can be produced experimentally by the method of Powers.

Use of Vision.— For consistent success in surgical measures the aid of vision is essential. The invention of a cardioscope by Allen and Graham was therefore a notable achievement. Their original paper should be consulted for the details of the instrument. Cutler tried to combine the principles of the cardioscope in his cardio-valvulotome with its extremely powerful cutting device, but apparently was not impressed with the vision afforded. The following experiments were conducted with a view to establishing a method of operating on cases of mitral stenosis, and it seemed obligatory to employ an instrument by which the valve could be cut under the guidance of the eye.

PERSONAL EXPERIENCES.

To widen the orifice of the mitral valve, and so produce mitral incompetence, the valve was approached from above. Through the left auricular appendage an instrument was introduced by which a piece of valve could be excised and removed, using the principle of operating under vision. For reasons already stated, the method is the most likely to achieve success in operations on human beings for mitral stenosis.

The Instrument.—This is built around a straight hollow metal tube, the ends of which are closed with glass windows. Illumination is provided by a battery in the large proximal handle, which also contains a bulb, a focusing lens, and a switch at its lower end. The light is reflected down the main tube by a reflecting mirror with a central opening.

On the outside of the tube are the parts for partial valvulectomy, which comprises excision of a piece of valve and its removal from the circulation. This section is in two portions—one a ring, for trapping the valve and holding it against the distal window, and the other a circular shear which passes distally outside the ring and cuts the portion of valve enclosed in the ring. The ring has three teeth projecting proximally, and is mounted on a rod

which runs in a groove on the under surface of the instrument and ends proximally in a collar. To the collar are attached a handle on the under surface, and a spring catch which works on a ratchet on the side of the instrument. The collar is held against a circular spring by the catch engaging in the teeth of the ratchet. The circular shear has a sloping cutting edge and is borne on a rod which runs on the upper surface of the instrument and ends in a handle, which works against a spring. The distal portion of the instrument behind the shear and ring is furnished with an extra casing which is perfectly cylindrical in shape and encloses the rods bearing the ring and shear.

An accessory portion of the instrument is the sheath. This is a light metal tube of constant bore. At its middle is a thin metal platform which swings outwards on a hinge. The platform, when engaged, closes the lumen of the sheath, forming a watertight diaphragm, and when swung outwards leaves

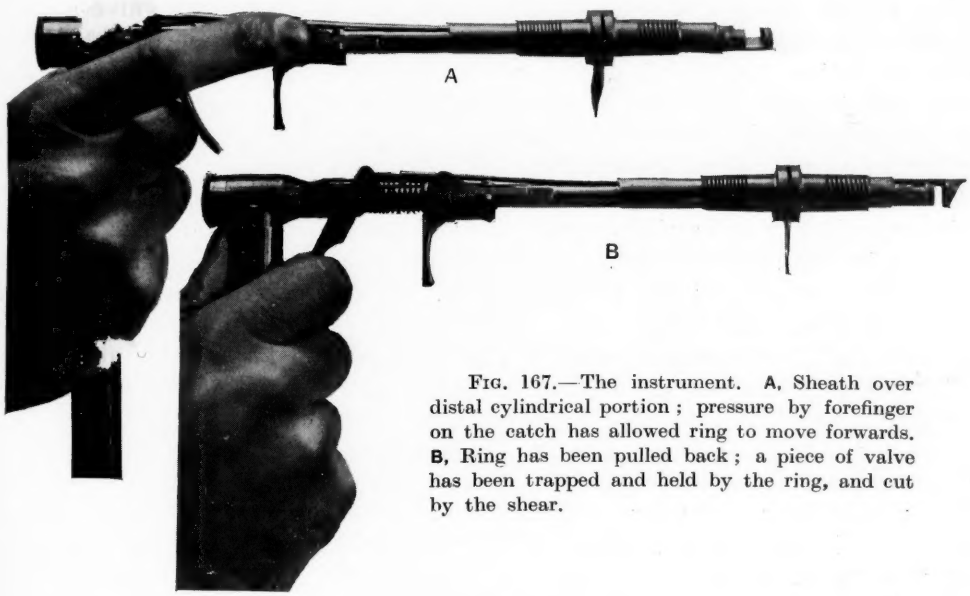

FIG. 167.—The instrument. A, Sheath over distal cylindrical portion; pressure by forefinger on the catch has allowed ring to move forwards. B, Ring has been pulled back; a piece of valve has been trapped and held by the ring, and cut by the shear.

the lumen entirely clear. At the ends of the sheath are a number of grooves which give a firm grip to a ligature. The bore of the sheath is 9·5 mm. The distal cylindrical part of the instrument fits the sheath closely. The instrument can pass smoothly through the sheath without allowing the escape of blood. Its total length is 25 cm.; the outside diameter of the ring is 8 mm. The instrument will cut and remove a piece of valve which is almost circular in shape and measures 8·5 mm. in diameter. It can be sterilized by immersion in carbolic solution or by formalin vapour. Boiling causes condensation on the inside of the windows. The battery is inserted into the main handle after sterilization of the instrument.

Technique of Partial Valvulectomy.—The left auricular appendage is clamped at its base by a weak-jawed clamp with curved blades protected by rubber. The appendage is opened by cutting off its tip and its cavity

washed out with normal saline solution. The sheath is then tied into the appendage by a purse-string suture reinforced by a ligature. Waxed silk or linen thread is employed as suture material. The sheath platform is closed and the clamp released. The instrument is introduced into the sheath, the platform opened, and the instrument passed at once into the heart cavity. The light is switched on. As it closes the mitral valve impinges on the end of the instrument, and may be seen at the moment of impact. The operator aims at excising a portion of the aortic cusp of the valve. Pressure on the catch is made by the forefinger, and the ring passes into the ventricle beyond the valve (*Fig.* 167 A). Traction on the ring handle brings back the ring, which then holds a piece of cusp against the distal window. The cusp is held securely by the teeth in the ring, and the position of the ring is fixed by the catch engaging in the teeth of the ratchet. The trapped portion of the valve is in close contact with the window and can be examined by the eye at leisure. The valve is then cut by manipulating the shear handle (*Fig.* 167 B). Repeated strokes of the shear can be made if the valve is very tough. The excised portion of valve is held by the ring and removed from the circulation when the instrument is withdrawn. As the distal end of the instrument passes beyond the middle of the sheath during withdrawal the platform is closed. Finally the base of the appendage is clamped and tied. The stump may be cut away.

Criticism.— In animals with normal healthy valves the operation is not difficult. It can be carried out without the loss of any blood. The use of a sheath is attended with several advantages over the method of tying the end of the instrument into the appendage. Introduction is easier and safer, exploration and examination of the heart cavity can be made with greater facility and over a wider range, the instrument can be withdrawn for the purpose of cleaning it or to examine the excised portion of valve, and can be re-inserted immediately to repeat the procedure if necessary.

On the whole the instrument combines satisfactorily the principles of the cardioscope and the powerful cutting mechanism of the valvulotome. The portion of valve trapped by the ring is held securely by the teeth in the ring, is brought against the distal window, where it can be examined by the eye, and, after being cut free, is removed from the circulation. The shear is an efficient cutting device. A special advantage of the arrangement for excision is that repeated strokes of the shear can be made to cut the valve without any risk of losing the excised piece. With Cutler's valvulotome it is necessary to complete with one stroke the separation of the piece between the cutting edges. The lighting system has two main conveniences: (1) There are no connecting wires, and thus manipulation of the instrument is facilitated; (2) The arrangement of a proximal reflecting mirror gives a larger field for examination than the system in which the light is supplied by a small bulb set inside the tube close to the distal end. The area available for examination through a narrow tube is considerably reduced by the latter system, although this provides superior illumination. The sloping mirror reflecting light from a large bulb gives better illumination than an arrangement of small bulb and prism as used in an ophthalmoscope.

The feature of the instrument and method which is least satisfactory

is the visual section. The degree of vision is disappointing, and certainly does not permit of easy and rapid identification of structures. Cutler also, in his attempt to design a cardioscopic valvulotome, had a similar experience. An invention providing good vision in opaque media such as blood is probably essential to the solution of this problem.

Experiments in Partial Valvulectomy.—

1. *On Normal Animals.*—A piece of mitral valve was excised in three dogs. The operations were tolerated well, and the animals were killed at intervals of from six to fourteen months later. In all there was some degree of hypertrophy of the left ventricle. The edges of the artificial valvular defect were smooth and rounded. There was no sign of clotting of blood.

2. *On Animals with Mitral Obstruction.*—Three dogs (Nos. 30, 31, and 36) were subjected to operation. Mitral obstruction had been present for six months, four months, and three months respectively, and the results of obstruction in each have already been quoted in *Tables II* and *III*.

Dog 30 died during the operation. There was definite evidence of myocardial impairment before the procedure. A marked degree of mitral obstruction had been created. At the operation an obstructing pericardial strip with an attached piece of mitral valve cusp was first excised. To ensure a definite incompetence of the valve a further piece of the aortic cusp was removed. Shortly afterwards the heart dilated and stopped beating. Death was due, apparently, to the sudden production of an excessive degree of mitral incompetence.

Dog 31 died two days after operation. Examination showed œdema of the lungs. The heart seemed unable to tolerate the sudden change from obstruction to a fairly well-marked incompetence of the mitral valve.

Dog 36 made an excellent immediate post-operative recovery. The animal was found dead on the morning of the sixth day after operation. Death was unexpected, and no obvious abnormality was found post mortem. The excised portion of valve was smaller than in the other animals.

It would not be permissible to draw conclusions from these experiments. The number of experiments is too small, and the animals have not survived for a period sufficient to afford an opportunity of estimating the effect of the operation by physiological tests. There are, however, indications that the heart cannot easily withstand a sudden change from obstruction at the mitral valve to a marked degree of incompetence. It has been shown by Cutler that the healthy animal will succumb if a severe grade of mitral incompetence is produced. During this investigation experience of the operation of partial valvulectomy in normal animals and in animals with mitral obstruction suggests that in the former a larger piece of mitral valve can be removed with safety than in the latter.

TECHNICAL CONSIDERATIONS OF EXPERIMENTAL CARDIAC SURGERY.

Success in an investigation such as has been described depends largely on surgical technique, and consequently the very best conditions for operative work are required. Fortunately these were available in the Department of Experimental Surgery at Edinburgh. The most important requirements are

a safe and reliable method and control of anæsthesia, a rigorous aseptic régime, and correct management of operative technique.

The majority of the experiments were carried out on dogs, a few only on cats. In both the heart is approached by the transpleural route, therefore some form of positive pressure apparatus is required for anæsthesia. We employed intratracheal insufflation of ether. A current of air from an air-pressure pump is led through a bottle of ether; provision is made for mixing ether vapour and air and also for alternating the current. A gum-elastic or straight metal tube is introduced into the trachea and connected with the pressure apparatus. If a gum-elastic tube is employed, it should be protected in the mouth by a gag. The tube should so fit the opening of the glottis that air can return freely while the lungs are kept distended by a current of air under moderate pressure during the time the thorax is open. If the intratracheal tube is too large, regulation of the concentration of anæsthetic vapour in the lungs becomes very uncertain, while with a tube too small it is difficult to secure efficient aeration without excessive ventilation of the lungs and consequent loss of carbon dioxide.

The standard of asepsis must not be lower than that for operations on human beings. The operations in these experiments may be of considerable duration—even as long as three hours—and it is all-important to avoid infection from the skin surface by excluding the skin rigidly from the field of operation.

The thorax is opened through the fourth left intercostal space. Excellent access to the heart is afforded by this incision. To minimize adhesions after operation the lungs are protected by moist wool, and all cleansing in the thoracic cavity is done by suction over pieces of wool soaked in normal saline solution.

A few general principles of operations on the heart itself may now be enunciated. Control of the position of the heart is most easily maintained by using a silk suture inserted near the apex, as described by Cutler. Care is necessary not to kink the pedicle of the heart during manipulation. Damage to the main coronary vessels and to the conducting system must be avoided. Fine silk is the best material for suture or ligature. Cutler's method of crossed sutures efficiently controls hæmorrhage from the ventricle. Hæmorrhage from the auricles should be controlled by the use of a weak-jawed clamp and by subsequent ligature in order to approximate endothelial surfaces on the internal aspect and so prevent intracardiac clotting. For suture of the ventricles fine curved round-bodied needles are employed and a minimum of muscular tissue is included by the suture.

Several complications may arise during operation. When the heart is first exposed the auricles not infrequently pass into a state of flutter. The ventricles are unable to respond to the high auricular rate, and heart-block of 3 to 1 or 2 to 1 occurs. Though usually but momentary, the irregularity may be more persistent or may recur several times. The disturbance seems to be provoked by the mechanical stimulus of an instrument touching the left auricular appendage. Excitability to mechanical stimuli gradually lessens during operation. The heart may stop, following damage to the coronary supply or conducting system.

Apart from these, the gravest risk is from anoxæmia. When the thoracic cavity is opened the pressure is regulated, allowing a slight degree of collapse of the lungs in order to facilitate exposure of the heart. If the collapse is long-continued, some degree of stasis develops in the pulmonary circulation. Wrinkled blue patches appear over the surface of the lung, and ultimately deficient oxygenation of the arterial blood is witnessed by cyanosis observed in the heart itself. The lungs should be fully inflated at intervals to prevent the condition. Serious anoxæmia results in weakening and slowing of the heart-beat, and finally dilatation of the chambers and stoppage.

The best stimulant to the heart during arrest is manual massage and full inflation of the lungs, especially if there has been cyanosis. The circulation can be continued artificially by massage of the ventricles. Adrenalin injected into the cavity or dropped on the surface of the heart is efficacious also. Hot saline damages the epicardial lining.

Danger after operation may arise from 'heart tamponade'. To avoid this the edges of the opening in the pericardium should be approximated with interrupted silk sutures set at least one centimetre apart. Any reactionary effusion will thus be enabled to pass into the pleural cavity.

During closure of the wound the lungs are kept inflated by continuous pressure to expel air from the pleural cavity. The ribs on either side of the intercostal incision may be brought together by one or two sutures to relieve the tension on the muscles. Accurate approximation of the divided muscles in layers is essential for good healing. No skin dressing is required.

On the experience of more than fifty operations in animals it can be affirmed that the heart is remarkably tolerant of operative trauma. Two animals died during operation—one from failure of the anæsthetic apparatus, and one as a result of operative procedure. Two died within a few days of operation as a result of avoidable errors in technique—one from sepsis and one from hæmorrhage. Five died at short intervals after operation as a result of the operative procedure—two from intracardiac clotting after the insertion of fascia lata to produce mitral obstruction. Death was unavoidable in three of the nine fatalities, and the mortality from operation might be estimated at 12 per cent. In half the fatal cases death followed a second operation of partial valvulectomy for mitral obstruction. The remaining animals lived in good health until killed for examination at intervals up to fifteen months after operation. An operation on the heart is certainly tolerated by the healthy animal at least as well as an operation of the same duration, and of comparable severity, on any abdominal organ.

SUMMARY.

1. Surgical treatment of mitral stenosis involves converting the condition of stenosis into incompetence of the valve.

2. There is as yet no proof that the heart in which the mitral valve is stenosed can readily tolerate a sudden change to incompetence, nor that such a change will be beneficial.

3. In an experimental investigation it was decided to study the effects

of a mechanical obstruction at the mitral valve, and of a subsequent change to incompetence of the valve.

4. An original method was evolved of producing mitral obstruction, and the effects of obstruction on the heart and circulation are recorded.

5. Methods of surgical relief for mitral stenosis are discussed. A new instrument for performing partial valvulectomy under vision is described.

6. Experiments in converting mitral obstruction to incompetence are not of sufficient number and duration to offer evidence of value on the main question. The investigation is not yet complete.

7. Experiences in the technique of operations on the heart in animals are contributed.

I wish to record my appreciation of the continued interest shown by Professor D. P. D. Wilkie and of the encouragement received from him during the investigation. For the electrocardiographic records I am indebted to Mr. J. Y. Bogue, of the Pharmacology Department, University of Edinburgh. The work was carried out during tenure of the British Medical Association Research Scholarship and the McCunn Medical Research Scholarship. The expenses were in part defrayed by a grant from the Moray Fund, University of Edinburgh.

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SOME COMPLICATIONS OF HYDATID DISEASE.*

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A FULL consideration of the various complications which may occur during the life of a hydatid cyst is beyond the scope of this article, but it is felt that a general survey is possible, and that in such a manner attention will be drawn to some recent advances in the pathology and clinical aspects of this disease which are not yet sufficiently appreciated and are of fundamental importance to an understanding of much that has been misinterpreted in the past. In all countries it is the onset of complications which alone determines the first clinical manifestation of hydatid disease in nearly three-quarters of the cases, so that, although no new facts will be brought forward in this review, it will require no apology if it succeeds in reviving interest in some of the most important of these complications and their sequelæ.

THE TYPICAL UNCOMPLICATED CYST.

Development. — Following ingestion of the ovum, the hexacanth embryo hatches in the upper part of the alimentary canal, makes its way into radicles of the portal vein, and as a rule lodges in the liver. A hydatid follicle is formed there by the accumulation of mononuclear and eosinophil leucocytes around the parasite, which becomes vesicular at the end of two or three weeks. Fluid is formed within the laminated layer, and ultimately, with the same dramatic changes which characterize the growth of all embryos, a univesicular cyst is formed (*Fig.* 168). As this grows the tissue reaction in the host leads to the formation of an adventitious capsule. At first this is highly cellular, but as the parasite elaborates a semipermeable laminated cuticle, and the absorption of hydatid products ceases, it becomes replaced by concentrically arranged fibroblastic cells. Further extension of the cyst takes place by a quiet pressure necrosis of surrounding tissue and its replacement *pari passu* with fibrous tissue. This adventitia merges gradually and intimately into the tissues of the host, and in old large cysts may become very thick and dense.

Huxley introduced the term 'ectocyst' to denote the fibrous tissue derived from the host, to distinguish it from the parasitic layer, which he called 'endocyst'. These terms have led to endless confusion, and I consider that they should be abandoned—the term 'cyst' being used for the parasite, and 'adventitia' for the fibrous capsule derived from the host.

In its fully developed state the cyst consists of a double-layered parasite with enclosed specific fluid in which float the reproductive elements.

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* Based on a Hunterian Lecture delivered at the Royal College of Surgeons of England on July 10, 1930.

The outer layer of the parasite or the laminated membrane is a creamy-white structure which has remarkable properties and important functions. It varies in thickness with age and is laid down by the inner nucleated germinal layer. Chemically it is composed of hyalin—a peculiar substance somewhat allied to chitin. Histologically it is homogeneous, it contains no nucleated material, and is arranged in concentric laminæ, so that it resembles no other pathological product. The laminations are laid down from within out, so that the outer are stretched more than the younger inner layers. As a result they often show fissures and signs of moulting, and when the cyst is torn they contract more than the inner so that the whole cyst tends to turn inside out. The larger the cyst and therefore the thicker the laminated layer, the more complete is this eversion.

It is possible that this peculiarity may have a biological significance in that it ensures shedding of the reproductive elements and makes them readily accessible to the carnivorous definitive host. This layer also gives rigidity and support to the delicate germinal layer and to the developing reproductive elements. In addition it has a special selective permeability, which not only ensures retention of the specific hydatid fluid at a fairly high tension, but also prevents the entrance of noxious substances from the host. It is therefore above all a protective layer, and on its integrity seems to depend the maintenance of ideal conditions for the development of the all-important reproductive elements.

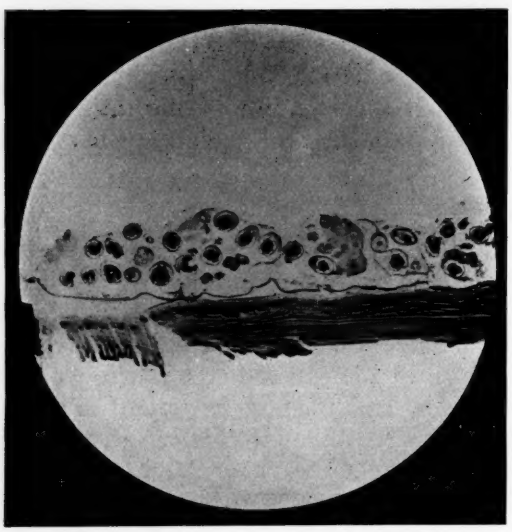

FIG. 168.—Section of the wall of a typical univesicular hydatid cyst, showing laminated layer, blood capsules, and scolices. (Oc. 2; Obj. 3.)

The inner delicate nucleated germinal layer is in close contact with the laminated layer. It elaborates both the laminated membrane and the specific fluid, and from it are developed the scolices or future worm heads. The specific fluid is clear, carries only a trace of protein, but has a very highly saline content and contains some specific hydatid substance. It is a nutritive fluid, and no doubt must be kept at a constant composition for normal development of the scolices to proceed.

The scolices, unlike those of cestodes, are developed in groups inside specialized sacs or brood capsules. They are just visible to the naked eye (measuring up to 160μ in the resting state), and are seen in all stages of development—from the undifferentiated cellular bud to the fully developed scolices with suckers and hooklets and contractile tissue. They are in reality the larval form of the worm, and may be present in thousands in a single cyst. With the formation of scolices the cyst has reached its full development, and it is only necessary for some of them to be ingested by the correct

definitive host for the life-cycle to be completed by the development of mature ova-producing worms.

Clinical Aspects of the Simple Cyst. — These simple cysts are typically found in children and young adults. It is extremely important to realize that the majority of hydatid, like all parasitic, infestations take place in childhood, so that the majority of cysts are nearly as old as the patient harbouring them. This is borne out by evidence from all sides, and its recognition has had a profound influence on our appreciation of much of the pathology of the disease.

The outstanding element characteristic of these cysts is their latency. They may exert pressure on any structure, and, since practically any organ may be involved, it can readily be understood that bizarre and protean manifestations may be produced. Small cysts in special situations such as the orbit, the cranial cavity, or the spinal canal may of course produce grave symptoms relatively early. Deformity may be produced, especially in children, but it is notable that large cysts can be tolerated. This is not to be wondered at when one considers the frequency of infestation during the growing period, the extremely slow growth of the cyst which enables compensatory changes to occur, and the fact that cysts are often shut off from the body fluids of the host by a relatively impermeable fibrous adventitia.

Ultimately, however, some complications of the cyst occur, and it is obvious that the frequency of such complications increases as age advances and the cyst increases in size. It is found that they are relatively rare in young subjects, manifesting themselves usually between 25 and 80 years of age. Practically all these complications depend on a previous escape of fluid from the cyst, this varying from a slight leak, which is often unnoticed or masked by other symptoms, to a frank rupture.

Rupture of the Cyst.—As the cyst enlarges it may encroach on a natural channel, a hollow viscus, or serous cavity—one area of the laminated membrane thus becoming relatively unsupported. As a result it may give way spontaneously, even during sleep, following muscular movement, coughing, or straining, or more commonly following direct mild or severe trauma such as a blow, a fall, a crush, or a perforating injury. As a result the tear in the laminated membrane, which rapidly enlarges owing to the peculiar grain of this structure, allows the escape of the contained fluid and hydatid elements. Such rupture takes place most commonly into the subcutaneous or muscular tissues, into the bile-ducts, bronchi, alimentary canal, or urinary tract; into a serous cavity such as the peritoneum, pleura, or pericardium; or into the chambers of the heart or large veins. More rarely rupture occurs into the ventricles of the brain, the spinal theca, or on to the exterior of the body.

Each of these has its own characteristics, and as some of them may be combined in the individual case it will be readily understood that a complete discussion is outside the scope of this review. It is found, however, that the sequelæ may be grouped together in the following way :—

(1) General—applicable to practically all types: (*a*) *Immediate*—hydatid anaphylaxis; (*b*) *Delayed*—secondary echinococcosis.

(2) Special—applicable particularly to cases of rupture into a natural channel: (*a*) *Immediate*—mechanical effects; (*b*) *Delayed*—suppuration in the cyst.

HYDATID ANAPHYLAXIS.

Many clinicians have noted the appearance of peculiar toxic manifestations following puncture or rupture of hydatid cysts. The most common of these is the hydatid rash, characterized by irregularly distributed urticarial wheals with general or localized erythema and pruritus. Other symptoms of variable occurrence are dyspnœa and cyanosis, abdominal pain, vomiting and diarrhœa, syncope, delirium, or nausea. Profound cardiovascular shock may dominate all the symptoms, and on rare occasions lead to fatal termination.

The close resemblance between the clinical picture in these cases and that associated with anaphylaxis due to foreign proteins, the presence of sensitiveness to hydatid fluid in patients with hydatid disease as shown by the well-known intradermal test of Casoni, together with the variable power of inducing passive sensitization by injecting their serum into suitable animals, make it almost certain that the majority of the symptoms which follow rupture of hydatid cysts are anaphylactic in nature.

A patient with hydatid disease may absorb varying amounts of hydatid antigen. This absorption probably takes place readily during the early stages of development of the parasite before the impermeable laminated membrane is fully elaborated. The occurrence of a specific cellular reaction around the early follicle favours the view that products of parasitic metabolism may then be diffused, and at the same time, since the infection is doubtless often multiple, other embryos may be destroyed in the tissues with the liberation and absorption of hydatid antigen. As a result, specific sensitization of the cells of the host takes place, and if at any later period even small amounts of hydatid fluid are absorbed into the circulation, anaphylactic symptoms of varying severity occur. The degree of sensitization varies greatly, but the relatively high percentage of positive findings with the intradermal test of Casoni shows that it can occur even in uncomplicated cysts in which leakage of fluid has not occurred.

There is no doubt that during the life of most cysts leakage does occur, and that, were more accurate histories possible, clinical evidence of anaphylaxis would often be obtained. In some instances the only effect may be the production of desensitization, but in the majority of cases symptoms would occur. Following the initial symptoms recovery is the rule, but after a period of two or three weeks the patient may become again sensitized, so that a subsequent leakage may be followed by even more striking manifestations. That some of these patients become extremely sensitive is borne out by the fact that I have seen the most alarming symptoms after the intradermal injection of 0·25 c.c. hydatid fluid for the Casoni test. As pointed out above, the clinical picture is very variable, and *Table I* emphasizes this.

Clinically there are three main types of cases—the common benign, the severe, and the grave cases. In the first type the usual manifestations are cutaneous, but there are often other symptoms such as faintness, dyspnœa, vomiting, and irregular pyrexia.

Table I.—ANAPHYLACTIC SYMPTOMS IN 20 CASES OF HYDATID DISEASE.

SITE OF CYST	COMPLICATION	CASONI TEST	DYSPNŒA	COUGH	CYANOSIS	CARDIAC	AGITATION	PYREXIA	URTICARIA	PRURITUS	VOMITING	DELIRIUM	PULMONARY ŒDEMA	DILATED PUPILS	DEATH	REMARKS
Liver ..	Bile-duct rupture ..	?	+	+	+	+	+	+ D	+ D	+	+	−	−	+	−	Three attacks
Heart ..	Rupture	?	+	+	+	+	−	−	−	−	−	+	+	+	+	
Lung ..	Cardiac rupture ..	?	+	+	+	+	−	−	−	+	−	−	+	+	+	
Spine ..	Rupture of D. cysts ..	+	−	+	−	+	−	+	+	+	−	−	−	−	−	Repeated post-operative
Liver ..	Bile-duct rupture ..	+	+	+	+	+	+	+	−	+	+	−	−	−	−	Many previous operations
Liver ..	Bronchial rupture ..	+	+	−	−	−	−	−	+	+	−	−	−	−	−	In convalescence
Liver ..	Casoni test	+	+	+	+	+	+	+ D	−	−	+	+	+	+	−	Very small dose
Lung ..	Rupture into P. artery	?	+	+	+	+	−	−	−	+	−	−	−	+	+	
Liver ..	Peritoneal rupture ..	?	+	+	−	+	+	−	+ D	−	−	−	−	+	−	
Liver ..	Pleural rupture ..	?	+	−	−	+	+	+ D	−	+	+	−	−	−	−	Post-operative
Liver ..	Biliary rupture ..	?	+	−	−	+	−	+	+	+	+	−	−	+	−	
Liver ..	Pleural rupture ..	?	+	+	+	−	+	+	+ D	+	−	−	+	−	−	Post-operative
Liver ..	Bile-duct rupture ..	?	−	−	−	−	+	+	+	+	+	−	−	−	−	
Lung ..	Pneumothorax ..	?	+	+	+	+	+	+ D	+ D	+	−	−	+	−	−	
Liver, Omentum	Rupture	?	+	−	+	+	+	+	+	−	+	−	−	−	−	Many previous operations
Pelvis ..	Leak	?	+	+	−	+	−	−	+ D	+	−	−	−	−	−	
Omentum	Leak	?	+	+	−	+	+	+	+ D	+	+	−	−	−	−	
Liver ..	Post-operative ..	+	−	−	−	+	−	+ D	+ D	+	−	−	−	−	−	After eight days
Liver ..	Peritoneal rupture ..	+	−	+	−	+	−	+ +	−	−	−	+	−	−	−	Post-operative symptoms
Liver ..	Puncture	?	+	−	+	+	−	−	+ i.m.	+	+	−	−	−	−	

D = Delayed reaction.

Severe cases are quite common, particularly after exploratory puncture or rupture into a serous cavity. It is important to remember, however, that similar cases may follow rupture into the bronchi, bile-ducts, or any other natural channel. Dyspnœa, cyanosis, collapse, nausea, vomiting, and weak pulse are the common initial symptoms. Urticaria may be entirely absent in the early stages, or be delayed for thirty-six hours, when it may lead to a retrospective diagnosis; occasionally it may not be observed at any stage. The classical examples occur following rupture of a hepatic hydatid into the peritoneum, the condition not infrequently being regarded by the clinician and patient as gastro-enteritis or food poisoning, particularly if there is a history of the ingestion of fish of any description. The dramatic onset with pain, the rapid recovery within a few hours, the intense nature of the urticaria, the non-persistence of vomiting and diarrhœa, and occasionally the previous history, should make one suspect that it is not gastric in origin. It must be remembered, too, that the peritoneum is surprisingly tolerant of the non-irritating hydatid fluid, and after the first few hours abdominal rigidity and tenderness may be completely absent in these cases. All of them react dramatically to an intravenous injection of 10 min. of adrenalin.

The grave cases are rare, occurring typically after rupture into the cardiovascular system, although fatal cases have been recorded after simple puncture of a cyst. Pulmonary and nervous symptoms predominate, urticaria and erythema being rare, although pruritus may be intolerable.

It is necessary to mention another type of anaphylactic phenomenon, and we are indebted to Dévé[1] for drawing attention to it. As general anæsthesia abolishes the anaphylactic state, it is rare for grave anaphylaxis to occur during or just after operation, even if large quantities of fluid are set free in the wound and absorbed. Sometimes, however, symptoms of this nature occur after operation, their appearance being usually delayed for thirty-six to forty-eight hours but lasting for some days. Urticaria is usually absent, and there is no absolute criterion whereby we can distinguish anaphylactic from ordinary post-operative shock; but all surgeons must have been struck by the frequency of unexplained post-operative reactions after hydatid operations, and there is no doubt that some of these are anaphylactic. In the past they have been explained, without any confirmatory evidence, as being due to reactionary pyrexia, operative shock, peritoneal reaction, post-anæsthetic vomiting, mild infection, etc. Grave symptoms, however, occasionally occur, and Dévé has collected a small series of fatal post-operative cases. It is probable that further careful observations on these or on other cases of hydatid disease will lead to the recognition of anaphylactic symptoms in more cases than is generally admitted.

SECONDARY ECHINOCOCCOSIS.

Rupture of a hydatid cyst or puncture by a trocar with evacuation of the specific fluid does not necessarily cause death of the parasite—probably it rarely does unless micro-organisms are introduced. The parasitic elements have such power of persistence that they can survive and ultimately develop into new cysts often at a distance from the original, this development being best described as secondary echinococcosis to distinguish it from

the development of cysts primarily from hexacanth embryos. For many years clinicians had noted the occurrence of multiple cysts, and although there were a few dissentients, these were regarded by the majority as due to multiple primary infestations. The history of the gradual recognition of the true nature of these cysts is of some interest. In 1793 the famous John Hunter, with characteristic acumen, first suggested that some abdominal and pelvic cysts were secondary to implantation of hydatid element from intraperitoneal rupture of a visceral cyst. Charcot and Davaine[2] criticized this view on theoretical biological grounds, and it was gradually forgotten until 1861, when Richard Bright,[3] although he made no reference to Hunter's original suggestion, revived it and pointed out the dangers of puncture and operative interference. In 1877 Potain[4] and Volkmann[5] also supported the hypothesis, and warned surgeons against the risks of dissemination of the disease by these agencies.

From this time onwards many surgeons in all countries made clinical and operative observations which bore out this view, although some of them believed that multiple cysts were due to implantation of daughter cysts. In Australia, Graham, Watson, and MacCormack were the chief upholders of the doctrine of implantation of scolices. In spite of these direct surgical observations, the majority of pathologists and helminthologists, although they believed that—as was proved experimentally by Lebedeff and Andrejew[6] in 1889—daughter cysts could implant, refused to countenance the view that such highly differentiated structures as scolices could, as it were, revert in their life-cycle. Even as late as 1900 such a view ranked with many authorities as a biological heresy, as it seemed contrary to all the laws of the development of the cestodes laid down by Van Beneden.

Further accumulated observations and experimental researches, however, have conclusively proved that such a retrogressive metamorphosis is not only possible, but that it is relatively common and of great clinical importance. Experimental work on the problem has been carried out and confirmed by d'Alexinsky[7] and Dévé[8] in Europe, Lagos Garcia in South America, and myself in Australia. Briefly, if washed living scolices are injected into rabbits by the subcutaneous, intramuscular, intraperitoneal, or intravascular routes, positive results with the production of secondary cysts are obtained in about 75 per cent of the experiments.

The vesiculation of the scolex is a relatively simple process. It becomes hydropic, its cells spread out on the inner aspect of the cuticle, which then rapidly thickens and becomes laminated. The only structures that persist are the hooklets which are found aggregated in a confused mass at one pole, but as the cyst grows they also become scattered and disappear. There is no doubt that many of the scolices are overwhelmed by the cellular reaction of the host, and undergo phagocytosis and fibrosis—a fact which is borne out by many clinical observations in the human subject. There seems little doubt that fragments of the original germinal membrane can also lay down protective laminated membrane around islets of nuclear material and also give rise to cysts.

From these and other correlated observations, therefore, has emerged the unique fact that such is the persistence of the parasitic elements that any

of them can, if shed into the tissues under aseptic conditions, implant and give rise to secondary cysts which may ultimately become fertile. Recognition of the frequency and importance of this has led to great advances in our conception of the pathology of hydatid disease.

Clinical Types.—There are many clinical examples of this phenomenon, as it can occur following practically any type of rupture, but reference will be made only to the localized, the peritoneal, and the metastatic types.

Localized Secondary Echinococcosis.—Rupture of cysts of the subcutaneous or muscular tissues, owing to their exposed position, is relatively common. As a result germinal elements, mainly in the form of young scolices, are shed into the tissues under aseptic conditions, and, although some of them no doubt are destroyed by phagocytosis, many survive and form multiple secondary cysts which by their growth often overwhelm the original primary cyst. They are comparatively uniform in size, and may be carried some distance by muscular action, particularly along perivascular and perineural sheaths. The name 'seed hydatids' which has been given to them is very appropriate. As is the case with most secondary cysts, degenerative changes with the production of cholesterin are common. Slight leakage of fluid from a simple cyst following puncture or mild trauma may give rise to a similar phenomenon within the confines of the adventitia—the fluid being absorbed and multiple cysts developing *in situ*.

This constitutes one of the commonest types of reactive daughter-cyst formation, and is the explanation of the reappearance of a multivesicular cyst, or cyst containing daughter cysts, at the site of a punctured or injured cyst. It is possible that the most logical way of looking at endogenous daughter-cyst formation may be to regard it as a special type of localized secondary echinococcosis—due to some complication which has not necessarily manifested itself clinically.

Post-operative recurrence in the original cyst, in the scar, or in the depths of the field of operation, constitutes another well-known type. Owing to the need of what are sometimes difficult and extensive operations to eradicate these recurrent cysts, this is often a serious matter, and until hydatid cysts are regarded as infective foci and respected as such, these cases will continue to be a feature of our records. They are nearly always due to the shedding of the easily missed scolices, and the method of preliminary sterilization by formalin introduced by Dévé, Quénu, and others, and now in general use throughout the world, should practically eliminate this sequela.

Secondary Cysts of the Peritoneum and Pelvis.—These are very common, and are always due to leakage of germinal elements from a primary cyst of the liver, or more rarely of the spleen, kidney, or omentum. A consideration of the possible sequelæ of rupture of a hepatic cyst is of interest in that it illustrates the protean manifestation of hydatid disease in this situation.

Occasionally the adventitia alone gives way, the intact parasite being extruded, coming to rest, and gradually acquiring a new adventitia, somewhere in the abdominal or pelvic cavity. As no fluid is shed this event may occur quietly, with no anaphylactic or other symptoms and no resultant secondary cysts. This is an explanation of one type of primary pelvic hydatid cyst.

Usually, however, the cyst ruptures, hydatid fluid and scolices being shed into the peritoneal cavity with some degree of anaphylactic shock as described above. The scolices may be shed in thousands, and are carried by the rush of fluid, by gravity, or by intestinal movement, to various parts of the cavity—as a rule to the lower quadrants. They soon become surrounded by lymph and eosinophil leucocytes and so rapidly fixed to a new secondary site. Doubtless many of them are overwhelmed and undergo fibrosis; sometimes the peritoneal or omental reaction around these disintegrating scolices is so extensive that a pseudo-tuberculous appearance and thickening of the peritoneum are produced (*Fig.* 169). Many, however, survive, become surrounded by a new adventitia, undergo vesiculation, and develop into secondary cysts. Just as in the case of any other foreign body introduced into a serous cavity, fibrotic encapsulation follows, the peritoneal epithelium gradually spreading over all until the secondary cyst gives the appearance of having developed in an extraperitoneal situation. It was non-recognition of this simple process that led many of the older pathologists to believe that these cysts were multiple primary cysts developed from hexacanth embryos brought to the subperitoneal zone by the blood-stream, or by direct migration from the upper part of the alimentary canal.

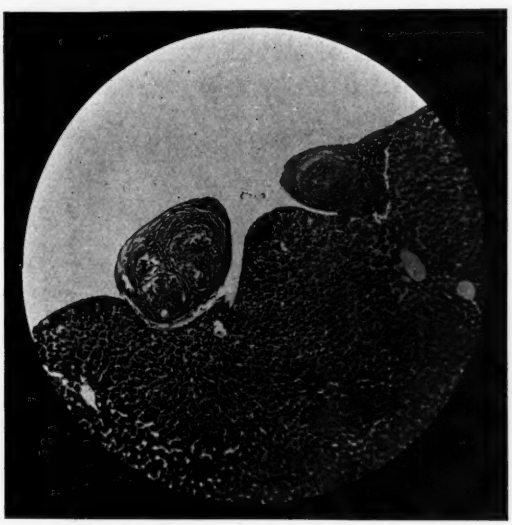

FIG. 169.—Formations of tubercles around disintegrating scolices on the edge of the liver following intraperitoneal injection.

These secondary cysts are of slow growth, so that there is always a latent period of from five to twelve years at least during which growth takes place until they in their turn produce symptoms. Owing to the rapid and complete recovery in most instances from the initial rupture, it is often misinterpreted by the clinician and its true significance is unrecognized until at a later date the discovery of multiple abdominal cysts leads to a retrospective diagnosis. It is thus not uncommon for this complication of intraperitoneal rupture of a visceral cyst to occur in youth, but for its clinical manifestation and recognition in the form of multiple abdominal cysts to be delayed till adult age is reached. Secondary abdominal cysts are always multiple, often irregular in shape and size, and owing to the relative tenuity of their adventitia are prone to further ruptures with repetition of the above effects. As a result, the whole peritoneal cavity may become filled with hydatid cysts in all stages of development—a very grave condition aptly described as hydatidosis.

It cannot be too strongly urged that, when multiple cysts are discovered in the abdomen or spleen, their secondary nature should be suspected and a search made for a primary visceral cyst. The original primary cyst may

be completely evacuated and replaced by fibrous tissue, so that after a lapse of years it may be impossible to detect the site except by very close examination. This is the explanation of some cases of obvious secondary abdominal cysts in which no primary cyst has been discovered at operation. Usually, however, the rent becomes occluded by adhesions and the residual germinal elements produce multiple daughter cysts—one type of localized secondary echinococcosis. It is a general rule, therefore, that when multiple simple peritoneal cysts are found there is also a primary visceral cyst containing daughter cysts. Somewhat similar phenomena to the above may occur following rupture of a cyst into the pleura or pericardium.

When a multivesicular hepatic cyst ruptures into the peritoneal cavity similar sequelæ occur, but owing to the frequency of communication with the biliary tract other possibilities arise. Although these are partly mechanical and partly infective, it seems appropriate to deal with them shortly here.

Because of the thickness of the adventitia and of the frequent presence of omental adhesions in these cases, rupture is less frequent and requires much greater trauma. As in the preceding type, hydatid fluid, débris, daughter cysts, and—if any of the latter are ruptured—scolices as well, are shed into the peritoneal cavity. There will be the same anaphylactic syndrome, the same risk of development of secondary cysts either from scolices or daughter cysts; but, in addition, bile in varying quantities may enter and lead to a choleperitoneum. This leakage of bile may occur at the time of rupture, or be delayed for some time until a bile-duct ruptures owing to removal of cystic support. The flow may be very slight or profuse, and the results vary greatly. The peritoneum is at first extremely tolerant, a biliary ascites developing slowly over a period of months. As a rule, however, the collection of bile becomes localized by adhesions and more or less encysted. As is to be expected, the diagnostic difficulties are great and errors are very common. In spite of this tolerance of the peritoneum, infection is introduced sooner or later, and although this is usually of low virulence, the hand of the surgeon is ultimately forced owing to the development of local peritonitis. Occasionally infection occurs coincidently with the biliary leakage, in which case a subphrenic abscess or various degrees of peritonitis rapidly develop. These pathological sequelæ of intraperitoneal rupture of a hepatic cyst are summarized in *Fig.* 170.

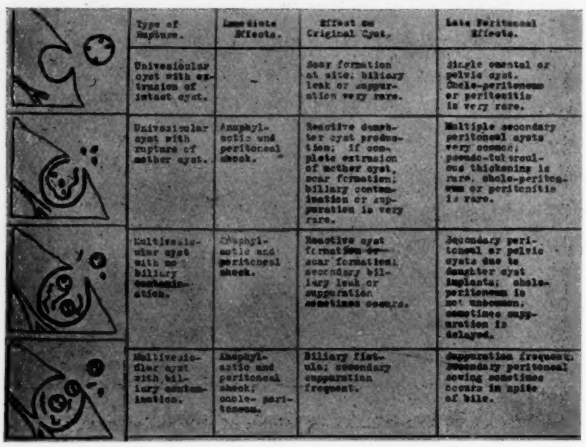
Type of Rupture.
Immediate Effects.
Effect on Original Cyst.
Late Peritoneal Effects.
Univesicular cyst with extrusion of intact cyst.
Scar formation at site; biliary leak or suppuration very rare.
Single omental or pelvic cyst. Chole-peritoneum or peritonitis is very rare.
Univesicular cyst with rupture of mother cyst.
Anaphylactic and peritoneal shock.
Reactive daughter cyst production; if complete extrusion of mother cyst, scar formation; biliary contamination or suppuration is very rare.
Multiple secondary peritoneal cysts very common; pseudo-tuberculous thickening is rare. chole-peritoneum or peritonitis is rare.
Multivesicular cyst with no biliary contamination.
Anaphylactic and peritoneal shock.
Reactive cyst formation or scar formation; secondary biliary leak or suppuration sometimes occurs.
Secondary peritoneal or pelvic cysts due to daughter cyst implants; chole-peritoneum is not uncommon, sometimes suppuration is delayed.
Multivesicular cyst with biliary contamination.
Anaphylactic and peritoneal shock; chole-peritoneum.
Biliary fistula; secondary suppuration frequent.
Suppuration frequent. Secondary peritoneal sowing sometimes occurs in spite of bile.

FIG. 170.—Schema of the possible sequelæ of intraperitoneal rupture of a hepatic cyst.

Metastatic Secondary Echinococcosis.—This gives rise to the rarest but the most interesting type of all secondary cysts, and is due to a rupture of a

fertile simple cyst into the heart or venous system. This type of rupture may take place on the venous side of the circulation into peripheral veins or the right chamber of the heart, or into the arterial side, when it always takes place into one of the left chambers of the heart. As a result two sets of sequelæ are possible. In both, of course, grave anaphylactic symptoms may occur, although as a rule recovery takes place.

If the cyst ruptures into the venous side of the circulation, the scolices are carried through the right ventricle into the lungs, where they are filtered out and give rise to secondary pulmonary cysts (*Fig.* 171). These metastatic pulmonary cysts are characterized by their multiplicity, their bilateral and peripheral distribution, and by their uniformity in size.

In the second variety the rupture always takes place into the left auricle or ventricle, the hydatid elements entering the systemic circulation and giving rise to metastatic cysts in various parts of the body. Owing to the position and relative size of the carotid arteries, the majority of scolices are carried to the brain, which becomes the seat of the majority (60 to 70 per cent) of these secondary cysts. Some scolices, however, often escape to the kidney, spleen, or liver, and there give rise to secondary cysts. All these are simple cysts of approximately the same size, rarely becoming larger than a hen's egg.

FIG. 171.—Radiograph of multiple metastatic pulmonary hydatid cysts.

The secondary cerebral cysts are in marked contrast to the single primary cysts of the brain in that they occur in the adult, while primary cysts occur classically in children. Indeed, primary cerebral cysts are very rare in adults—their frequency being only one-seventh of that in children. This is due to the fact that hydatid infestation usually occurs in children, and that cysts in this situation produce symptoms in a few years so that adult age is not reached.

The metastatic cysts are rare in childhood, because the cardiac cyst has to reach a certain size before rupture takes place—a matter of some years—and then the secondary cysts have to grow large enough to manifest themselves—also a matter of some years.

The original cardiac cyst may undergo obliteration by fibrosis, but as a

rule some germinal elements remain therein, the rent closes, and reactive daughter-cyst formation occurs in the original site. Provided the patient does not succumb to the effect of the metastatic cysts—a not unusual event when the brain is involved—the primary cardiac cyst later ruptures a second time, with, as a rule, fatal embolism by daughter cysts.

The clinical picture of these cardiac cysts is of great interest, and owing to careful pathological studies the whole story can now be accurately told. It may be divided into six phases as follows :—

1. Period of some years (ten to fifteen) during which growth of the primary cardiac cyst with no symptoms takes place.

2. Rupture of the simple cyst into the pericardium, or more commonly into one of the cardiac chambers, with a dramatic anaphylactic syndrome which is often misinterpreted.

3. Phase of latency (two to five years) during which the secondary cysts develop in the pericardium, lung, brain, or other organ ; the original cyst occasionally becomes obliterated by scar, but usually a multivesicular cyst containing daughter cysts re-forms in the primary site.

4. Rupture of one of the pericardial cysts may occur into one of the cardiac chambers, with repetition of phases (2) and (3).

5. Development of symptoms due to the multiple pulmonary or intracranial cysts, the latter often causing death.

6. If the patient lives long enough, a second intracardiac rupture of the now multivesicular primary cyst, with, as a rule, anaphylactic shock and death from daughter-cyst embolism of cerebral or pulmonary vessels.

It is therefore an important pathological point that the discovery of multiple pulmonary or cerebral cysts should direct attention to the heart, and vice versa.

These examples illustrate the classical manifestations of secondary echinococcosis, which is now clearly established as regards its etiology, pathology, and clinical aspects. It may be taken as a general rule, in the case of multiple cysts, that if the extrahepatic cysts are more than one-third of the total, it is probable that they are secondary cysts.

MECHANICAL EFFECTS OF RUPTURE.

The mechanical effects of rupture of a cyst are seen in cases of rupture into a natural excretory or secretory channel. Following the initial flooding with fluid, which is rarely serious, the passage of hydatid products along the channel leads to attacks of colic or intermittent partial or complete obstruction. These are as a rule more or less immediate effects, although they may continue for months as fractional evacuation of the cyst contents occurs.

It must be emphasized that micro-organisms do not find their way through an intact laminated membrane, and that in the case of simple cysts some degree of rupture of this membrane is an essential preliminary to suppuration. Once the hydatid membrane collapses, however, some serum is exuded into the cavity from the adventitia, and this with hydatid débris makes such an excellent pabulum for the growth of micro-organisms that when contact with a lining epithelium is made infection is usually only a

matter of time. There is no doubt, however, that small ducts or tracts may have at one time opened into the cavity and yet it may remain aseptic for years, and occasionally actual closure and repair of the opening may occur. Obviously the time that elapses between rupture and the introduction of infection must depend on a great number of variable factors, so that, although the introduction of infection may coincide with the rupture, it is usually delayed for weeks or months. As these two processes are closely bound up with each other they will be considered together in the following paragraphs.

Rupture of Hepatic Cyst into Biliary Passages.—Bile staining of multivesicular hepatic cysts is very common owing to the persistence of small bile-ducts in the adventitia and also the occurrence of previous leakage from the original simple cyst. As the cyst continues to enlarge, however, it may cause a quiet pressure necrosis of the wall of a large bile-duct, and if the opening becomes large enough some of the hydatid débris is forced into the duct. There is no doubt that such ruptures are relatively common, and I believe that some degree of intrabiliary rupture is the commonest of all the complications of hepatic cyst. This may be a mild quiet leak into the passage of fluid and small particles of débris, or a frank massive rupture with or without occlusion of the main ducts with daughter cysts. It is important to recognize that this rupture takes place most commonly into the intrahepatic portion of the ducts, this being one of the reasons why its frequency has not been generally recognized. *Fig.* 172 gives a schematic representation of the sites of this rupture.

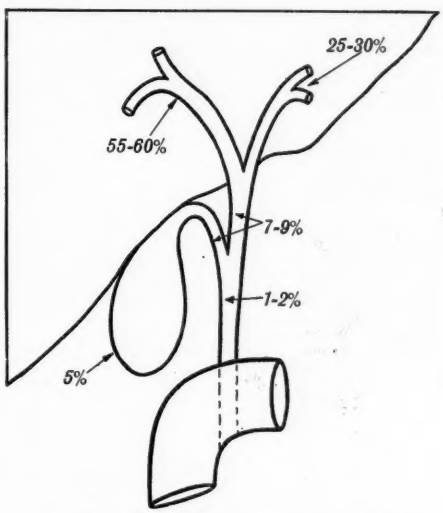

FIG. 172.—Schematic representation of the sites of rupture of hepatic cysts into the bile-ducts.

As a rule the biliary rupture takes place in cysts containing daughter cysts—according to Duprey in 93 per cent of a series of 55 cases collected by him. There seems little doubt that gross rupture, with the passage of collapsed or intact daughter cysts down the duct, is simply the culminating event of a series of minor ruptures. It is thus probable that the original rupture occurred years before, and owing to the maintenance of aseptic conditions and occlusion of the opening, reactive daughter-cyst formation occurred, giving rise to a multivesicular cyst in place of the mother cyst. Once rupture has occurred, the passage of the material down the ducts is helped by the intracystic pressure, diaphragmatic movement, and abdominal muscular action; and once started, the slippery non-irritating membrane is helped by the increased biliary flow after meals. In this way fractional evacuation of the cyst may take place into the duodenum. There may be, however, long periods of quiescence, so that months or years may elapse before all is evacuated.

The passage of débris or collapsed daughter cysts down the ducts, with varying degrees of pain, is the probable explanation of the pain experienced in most cases of complicated hepatic hydatid disease. This is a more reasonable explanation of the pain than pressure on the ducts, perihepatitis, hepatoptosis, or pressure on the cœliac plexus—explanations that have been advanced by clinicians in the past.

As a rule this is associated with biliary colic and transient or persistent jaundice; the biliary tree being at times markedly distended and the gall-bladder being found enlarged in 66 per cent of the cases. *Fig.* 173, for which I am indebted to Mr. B. T. Zwar, of Melbourne, illustrates the condition that is found in some of these cases. This radiograph was obtained by running 15 per cent sodium iodide solution into a left-sided hepatic cyst which extended into the right hepatic lobe, and which had ruptured into the biliary passages with the syndrome mentioned above. It shows very well the distension of all the biliary tree and the presence of the opaque iodide in the gall-bladder and duodenum.

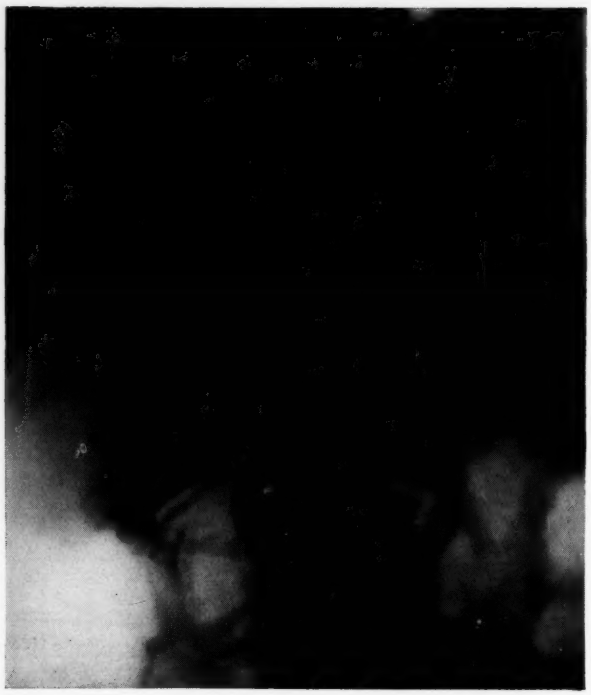

Fig. 173.—Radiograph obtained by the injection of 15 per cent sodium iodide into the biliary channels through a communicating hydatid cyst. (*By courtesy of Mr. B. T. Zwar.*)

In cases with this complication many puzzling variations of the pathological picture can occur—such as coexistent rupture into the bronchi, alimentary canal, or peritoneum, with consequent modifications of the clinical picture.

Owing to the presence of bile-stained débris in a cavity which is poorly drained, and to the frequency of attacks of obstructive jaundice, the patient is in imminent danger of severe or fatal complications. Suppuration is the most frequent concomitant of intrabiliary rupture, occurring in 60 per cent of all cases. There seems little doubt also that in the majority if not all cases of suppuration of hepatic hydatids some degree of intrabiliary rupture has occurred at one time or another. As is to be expected, this clinical condition simulates closely the migration of gall-stones, and the diagnosis of cholelithiasis is the commonest error in Australian surgical practice.

It is certain that, were it more generally recognized that hydatids not infrequently, and gall-stones comparatively rarely, involve the larger ducts, this diagnostic error would become less common.

The following points are of interest in the differential diagnosis :—

Age.—Hydatid disease involving the ducts tends to occur at a slightly younger age than stone in the common duct, i.e., 30 to 40 rather than 45 to 55.

Sex.—In hydatid disease males are found affected just as commonly as females, whereas in gall-stone disease females are four times as commonly affected as males.

Pain.—The pain of hydatid disease is not so severe as true gall-stone colic, owing to the non-traumatizing nature of the membrane.

Previous History.—In gall-stone disease there is nearly always a comparatively long history of flatulence, etc., which is often completely absent in hydatid disease, although in the latter there may have been attacks of an anaphylactic nature.

Examination of the Stools.—Examination of the fæces is the most important clinical method at our disposal, and should be used as a routine in all cases of jaundice. It is easily carried out by washing the fæces in a stream of water, when the tough bile-stained laminated membrane, which resists putrefaction in a remarkable way, is often discovered.

Hepatomegaly.—This is much commoner in hydatid disease than in gall-stones.

Jaundice.—This is characteristic of hydatid disease involving the ducts, being present in 80 to 90 per cent of the cases, while in gall-stone disease gross persistent jaundice is practically confined to cases of stone in the common duct.

Radiography.—This should be applied as a routine, as it may indicate subdiaphragmatic distortion or calcareous change in a cyst, while cholecystographic methods are of value in gall-stone disease.

Immunological Reactions.—These are of the utmost value, and the routine use of the hydatid complement-fixation test and the intradermal test of Casoni has revolutionized the diagnosis of hepatic hydatid in Australia.

With the onset of infection introduced by way of the biliary channels, the patient sooner or later, depending on the tension of the collection and the presence or absence of a valvular effect at the opening, shows evidence of intrahepatic suppuration and cholangitis, with rapid alteration of the clinical picture. It is a remarkable fact that in 15 to 20 per cent of the cases gas-producing organisms are present, and percussion and radiographic methods may detect the presence of a bubble of gas above the fluid in the cyst. In addition many other complications such as diffuse hepatitis, subphrenic abscess, peritonitis, empyema, and rupture into the bronchi may occur.

Hepato-bronchial Fistula.—This is not uncommon, and usually occurs in right-sided subdiaphragmatic cysts. The layers of the diaphragm and pleura are usually adherent from low-grade pericystic inflammation, and the cyst gradually penetrates through the lung and ruptures into the bronchus. When this happens the patient expectorates large quantities of daughter cysts and débris which is often stained with bile. It cannot be too strongly urged that the expectoration of daughter cysts, because of their rarity in purely primary pulmonary cysts, usually means that they originate in a hepatic cyst and that the sputum in these cases should be examined for bile. Sometimes the

cyst is non-infected at the time of rupture and fractional expectoration of the dependent cyst may proceed for months ; but sooner or later the poor drainage and the presence of a large bronchial communication lead to the introduction of micro-organisms and suppuration.

All sorts of variations of this pathological picture can occur, such as rupture into the pleura with the production of a chylothorax, a pyochylothorax, or a pyopneumochylothorax. At other times localized gangrene of the lung occurs in the region of the communicating track, while at others there is a coexistent rupture into a large bile-duct or into the alimentary canal, causing puzzling symptoms. These cases constitute some of the most difficult problems in hydatid disease, and unless the surgeon is alive to the possible vagaries of a large hepatic cyst, mistakes of diagnosis, treatment, and prognosis are inevitable.

FIG. 174.—Radiograph of simple pulmonary cyst before rupture.

In spite of the frequent proximity of cysts to the intestine, rupture into the alimentary canal rarely occurs. When it happens, evacuation with natural cure may follow; this depends on the size and site of the cyst and of the communication. There is, of course, a big risk of infective processes, and as a result the mortality in such cases reaches 50 to 60 per cent. In the same way rupture into the urinary tract may occur, with an almost exact simulation of renal colic due to stone. There is, as in the hepatic cases, the same attempt at fractional evacuation, the same intermittent blockage of the tract, the same risk of infection. The latter, which is often of a low-grade type, is usually delayed for years, and seems to be more or less dependent on the degree of obstructive hydronephrosis that is induced.

Rupture of a Pulmonary Cyst into a Bronchus.—This is the natural end of most pulmonary cysts, because by the time a cyst reaches a diameter of four to five inches it nearly always comes into contact with a large bronchus, the erosion of which causes a small part of the cyst wall to become unsupported. Following a cough, a muscular effort, an injury—or even spontaneously—the cyst wall gives way and the cyst contents enter a bronchus. Although partial rupture, with the escape of small quantities of fluid, may be masked by the accompanying hæmoptysis and bronchial

secretion, as a rule a comparatively large amount of fluid rushes into the bronchus with dramatic results. Rarely the patient is asphyxiated by the fluid or by the impaction of membrane in the glottis. As a rule, however, the severity of the symptoms is out of proportion to the amount of fluid expectorated, and it is probable that the persistent frothy sputum, dyspnœa, cyanosis, and general collapse so universally noted, are in the main anaphylactic in nature.

After rupture the patient usually recovers rapidly, although for some time repeated expectorations of fluid and gradual evacuation of the cyst contents may occur.

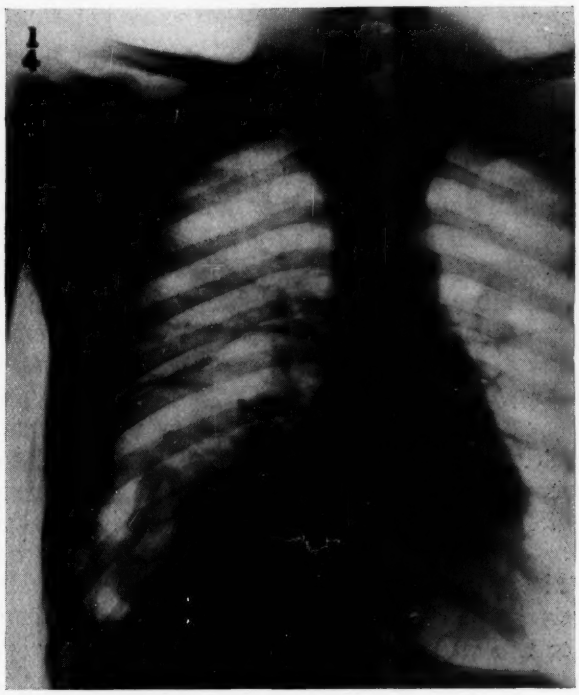

FIG. 175.—Radiograph of empty pulmonary cyst thirty-six hours after rupture. Same case as *Fig.* 174.

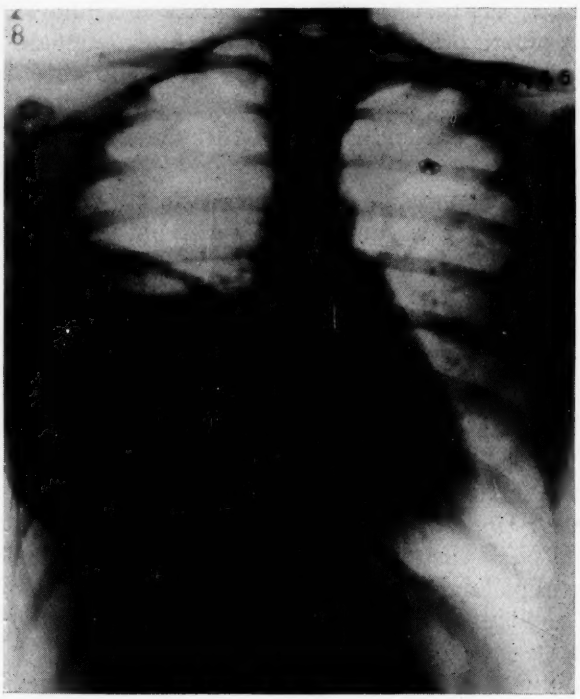

FIG. 176.—Radiograph of ruptured hydatid of the lung ten days after rupture, showing formation of a pneumocyst. Note fluid level with gas above it. Same case as *Fig.* 175.

The patient may have attacks of coughing and hæmoptysis but remain afebrile and in good health throughout, while natural cure, with collapse of the cavity and fibrosis, proceeds. Natural cure in this way depends on many factors. The size of the cyst is important, as on it will depend the thickness of the adventitia and therefore the possibility of complete collapse, and also the time taken for disintegration and expectoration of the cyst wall. As is to be expected, small cysts and cysts in children more readily undergo natural cure. The larger the bronchial communication and the more dependent its position, the better are the chances of evacuation. Apical cysts are

more likely to involve bronchi while yet small, and the opening will probably be dependent then, facilitating drainage. In the same way deeply placed parabronchial cysts will fulfil most of these conditions, and all are agreed that these cysts should not be attacked surgically, and that if left alone often about 75 per cent will undergo natural cure.

In a great many cases the contents of the cavity offer an excellent pabulum for bacterial growth, and owing to the bronchial communication organisms find their way in. At first these are saprophytic, but sooner or later pathological organisms, at first of low virulence, but later virulent cocci and often anaerobic gas-producers, enter. The adventitia become thickened and lined on the inner aspect with a pyogenic membrane, and all the signs of intrapulmonary abscess supervene with modification of the clinical picture (*Figs.* 174–176).

Suppuration of a pulmonary hydatid can only be produced in this way, and owing to the risk of extension in the lung and to the pleura may lead to grave sequelæ. Apart from these risks the prolonged toxæmia is of serious moment, and surgical intervention is usually required.

Hydatid Pneumothorax.—Another interesting type of rupture is that of a subpleural pulmonary cyst into the pleural cavity. This may be comparatively quiet, being associated only with immediate anaphylactic symptoms or the formation at a later date of secondary pleural cysts.

As a rule, however, the subpleural cyst is large enough to have involved a patent bronchus, in which case a pneumothorax follows the rupture. This hydatid pneumothorax, occurring as it does in a previously healthy patient, may be most dramatic in its onset. At first the effect is purely mechanical, although the mild irritation of the pleura often leads to a simple hydropneumothorax. In the majority of cases organisms are introduced from the patent bronchial opening and a pyopneumothorax develops. This may be delayed for days or weeks, but as a result the patient develops the signs of intrapleural suppuration.

It is obvious that this condition may be confused with tuberculous pneumothorax, but unlike that disease it is fairly common in adolescents; it is more common on the right side; there is rarely any suggestive previous history; there are no signs present on the opposite side; tubercle bacilli are absent from the sputum; anaphylactic symptoms are common; and the typical hydatid immunological reactions are often positive.

SUMMARY.

The various complications described above do not exhaust the possibilities, but they serve to illustrate the infinite variety possible, and to emphasize the fact that rupture, the formation of secondary cysts, and suppurative effects all combine to make hydatid disease a dangerous one for the patient and one full of problems for the clinician. In conclusion, the following facts, which are not always given sufficient prominence in discussion on the pathology of this disease, are reiterated:—

1. The majority of hydatid cysts are nearly as old as the patient harbouring them: complications increase in frequency as age advances, and practically all depend on some degree of rupture.

2. Hydatid anaphylactic symptoms are much more common than is usually recognized, and are evidence of leakage from the cyst.

3. Secondary echinococcosis is relatively common, and all cysts containing scolices must be regarded as infective foci and potential sources of dissemination of the disease.

4. Intrabiliary rupture of hydatid cysts of the liver is one of the commonest complications of hydatid disease in this situation, and the simulation of gall-stone disease may be very accurate.

5. Suppuration in hydatid disease is a severe complication and is always preceded by some degree of rupture.

I have to acknowledge the courtesy of the Australian Medical Publishing Company, of Sydney, for permission to reproduce several of the illustrations.[9]

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THE TREATMENT OF INFECTED OPEN FRACTURES.*

By ERNEST W. HEY GROVES,
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The importance of this subject can scarcely be exaggerated. Not only is this type of injury becoming more common every day, owing to the increasing prevalenee of machinery and road accidents, but also the results of treatment are often extremely bad in respect of loss of life, limb, or function. Further, a consideration of many of these bad results inevitably leads to the conclusion that treatment has been at fault and that lives, limbs, and function have been needlessly sacrificed.

There is a very real danger of the problems concerned being dealt with inefficiently, simply because they have become common or uninteresting. It is necessary to remind ourselves sometimes, when absorbed in the romance of modern surgical and scientific advance, that we must not neglect the common every-day injury, for by doing so we may cause the loss of life or limb just as certainly as if we failed to diagnose or treat some obscure disease of the brain or abdomen. Our responsibility in this matter is a very grave one, because the correct and timely treatment of an infected fracture can definitely save a life or limb, whereas the most intensive study of visceral disease will often only serve to mark the progress of an incurable malady.

Mistakes in the Treatment of Infected Fractures. — There are three common types of mistakes into which we are likely to fall in this matter. They are those of neglect, delay, or error of judgement. An injured man is brought to the casualty department of a hospital and is attended by a very recently qualified house surgeon. The wound is washed and painted with iodine, and the limb put on to a splint. The patient is then admitted to the ward, and very often nothing more is done until the next day, when a skiagram is taken. Such a routine really amounts to neglect, and would be considered so if the patient suffered from a punctured wound of the head, chest, or abdomen.

The fracture case may not be seen by an experienced surgeon for a day or two unless some grave symptoms arise. After a delay of one or two days the case is first seriously considered and a definite line of treatment adopted. Then if the skiagram shows badly placed bones or much comminution, the surgeon may be tempted to adopt some drastic treatment—for example, amputation, the plating of the fracture, or putting up the whole limb in plaster-of-Paris so as to hide the horrid sight under a white covering.

It must not be thought that in referring to these types of mistakes I am making an *ex-cathedra* denunciation of other people's sins. I am speaking of

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* Introduction to a discussion on this subject by the Association of Surgeons of Great Britain and Ireland in Bristol, on May 1, 1930.

things which have been done by myself or in my service, for which I am sorry, and which I hope will not be done again.

Experience shows that in the avoidance of these common mistakes three broad principles should be observed :—

1. Every infected fracture should be treated with the same care as would be given to a case of penetrating wound of the head or abdomen. The full surgical team should set about the problem, the pathological and radiographic departments giving the necessary co-operation.

2. This extensive examination and treatment should take place at once, with no more delay than is permitted in the case of a ruptured gastric ulcer.

3. The ultimate treatment of the fracture should be carried out in such a way as to assist and not endanger the primary object of curing the infected wound. Unless or until infection has been cured, drainage must be provided, and the infected tissues must not be loaded with foreign bodies. The limb must be put up in such a way as to give every assistance to free circulation of blood and lymph.

Results of Treatment.—The consideration of statistics of the results of open fractures is made difficult by many factors besides the obvious ones which beset all statistical investigations. Two of these difficulties may be mentioned. It is impossible to group together various bones for the purpose of the inquiry. We cannot compare events happening to a metatarsal bone or rib with those occurring in the femur. Further, it is quite impossible to have any measure of the degree of the original infection of the fracture, and it would be obviously absurd to compare results of a fractured tibia when a sharp fragment of bone just perforates the skin with those when the bone is crushed and the soft parts are cut by a dirty cart-wheel. In order to eliminate these two factors I have collected the last cases which have come under my own personal investigation of fractures of the tibia and fibula in which the wound was caused by direct external violence.

I have careful records of 50 consecutive cases of infected open fractures of the tibia and fibula, which show the following results :—

		Per cent
Deaths (following amputation) ..	2	4
Amputation	8	16
Good results	34	68
Poor results	7	14
Non-union	1	2
	50	100

These cases may be divided into recent cases, where we were responsible for the treatment from the outset, and old cases sent to us one or more weeks after the accident.

	Recent Cases	Old Cases
Deaths (following amputation) ..	2	—
Amputation	5	3
Good results	26 (74·3%)	8 (53·3%)
Poor results	4	4*
	35	15

* Including 1 non-union.

Death was due to gas gangrene (1 case) and streptococcal septicæmia (1 case). Apart from these cases, amputation was called for on account of damage to blood-vessels (secondary hæmorrhage, 1 case) or gangrene. Good results were obtained in three-quarters of the recent cases, and in about one half of the old cases.

Of the causes which contribute to these results four stand out for consideration: (1) The concurrent injury to the circulation producing traumatic gangrene; (2) An overwhelming virulent primary infection—these two causes of failure are inevitable and outside our power to control; (3) Delay in efficient primary treatment; (4) Faulty treatment of the fracture. It is these last two causes of failure which merit our close attention, because they are both under our direct control.

Delay in Efficient Primary Treatment. — This is perhaps the point of greatest practical importance, because it accounts for three-quarters of the failures and because it is due so often to sheer carelessness or procrastination. The common history of the case is this. A patient has a motor accident in some remote country place. He is taken to a nearby cottage hospital or doctor's surgery and the so-called first-aid treatment is applied. He is either detained for a few days or sent on by an ambulance to a city hospital, but in any case there is no serious treatment of the infected wound until one or two days have passed. It is very remarkable that at many country or cottage hospitals in which a perforated ulcer or acute appendicitis would be immediately recognized and operated upon, the infected limb wound is allowed to go out with nothing more than the most perfunctory treatment, although the opening up of such a wound with excision of the devitalized tissues is a matter of the utmost urgency and one which presents no great danger or difficulty.

Faulty Treatment of the Fracture. — The causes of failure under this heading are the faults of doing too little or the faults of doing too much. Doing too little in relation to the fracture is represented by the policy of simple splinting of the limb whilst the wound treatment is being carried out without any serious attempt to secure reduction of the fragments. This policy will certainly lead to gross malunion, which it will be very difficult to correct when the soft parts have healed.

The fault of doing too much is represented by the policy of indiscriminately removing bone fragments, and the even more dangerous practice of plating the septic fracture. Either plan involves grave danger of disaster: in one case by leading to non-union, and in the other to extensive necrosis.

The Treatment of the Infected Wound. — I feel sure that the guiding principle in these cases should be to regard them primarily as seriously infected wounds complicated by a fracture, and not as fractures complicated by a wound. There are two factors essential for effective treatment—timeliness and thoroughness. The sooner the better, and certainly within twelve hours of the accident, the patient must be anæsthetized in the theatre with all the skilled assistance used for any serious emergency. Excision of the edges of the skin wound, enlargement sufficient to allow full and deep exploration, removal of foreign bodies, any fragment of bone which certainly has no soft tissue connection, and careful cutting away of damaged tissues—

these are details familiar to every student of war wounds, and there is neither reason nor justification for varying them in the treatment of infected fractures in civil life.

Three points require further reference: X rays should be used before the primary wound treatment, if this will not involve delay. Their use may be of great value in revealing foreign bodies or in indicating the types of fracture. The use of antiseptics is certainly advisable. Either flavine (1–1000) or tincture of iodine followed by alcohol will be efficient, but their use is merely accessory to the removal of grossly infected tissues and can in no way be a substitute for it. The choice between primary, delayed primary, and secondary suture must be made according to circumstances. In favourable cases primary suture should be carried out, but even in these a deeply placed wick of vaseline gauze will be a measure of safety against residual infection. Material from the wound will be sent for bacteriological report, and prophylactic injections of tetanus and anti-gas serum will be given.

The Treatment of Comminuted Fracture Fragments and of Bare Bone.—The utmost conservatism should be observed in the treatment of loose pieces of bone and of the ends of the main fragments, which may be bare. Bits of bone which have no attachment to soft parts should be removed; but this is a very different thing from pulling on every piece of bone that can be seen or felt in order to find out if it will come away. Exposed bare bone should generally be left alone, though it is sometimes wise to remove awkward points which may press upon the skin or soft parts.

The Late Treatment of Infected Wounds.—If primary treatment has failed to get rid of the infection, or if the case comes for treatment two or three days after the injury, then—assuming that mechanical cleansing has been carried out—the question of drainage, irrigation, or packing will have to be decided. The Carrel-Dakin method should be reserved for bad cases with deep complicated wounds, as it is difficult to carry out efficiently for an occasional case. In the majority of cases daily irrigation with hydrogen peroxide, with the provision of drainage by gauze wicks soaked in paraffin or by rubber tissue, will meet the necessity of the mechanical cleansing and removal of discharge. At the end of a month or six weeks, if the discharge is still profuse, a search must be made for sequestra. In this the X rays will be the greatest value, because they will reveal the dead bone as dense shadows in contrast to the rarefied living bone.

The Primary Treatment of the Fracture.— Although I am strongly convinced that the treatment of the fracture should be secondary to that of the infected wound, yet from the very outset the fracture must be correctly treated, first in order to favour wound healing, and secondly to facilitate the final mending of the bone. All that is necessary to do for the fracture in the first stages of treatment is to secure immobilization and correct alinement. If fixation of the fracture is not attained, obviously the irritation caused by movements of sharp splinters of bone against the soft parts will cause effusion and inflammation, and make the very conditions which maintain and increase the infection.

The limb should be slung up in a Thomas or cradle splint with sufficient traction to maintain correct alinement. At this stage it is better to use

adhesive appliances for traction, and to postpone skeletal traction for the time being. It is neither necessary nor desirable to exert any great traction force at this stage, because the soft parts will heal more kindly if they are not subjected to great tension. The first stage in the fracture treatment is limited to about one week, during which time the wound will be well on its way to healing either by first or second intention.

The Final Treatment of the Fracture.—Within a few days of the injury, and directly the infection has been overcome, the fracture must be put up in such a way as to secure full-length and good alinement whilst allowing continuance of the wound treatment. For this the one safe and efficient method is skeletal traction. The general procedure and the advantages of this method are so well known that it would be waste of time to describe it in any detail, and reference will be made only to certain points that are worthy of emphasis.

I have never been converted to the idea of the ice-tongs caliper; it is liable to become displaced during manipulation, it tends to drag, and is much more painful than a transfixion pin. For fractures in the lower end of the femur with wounds near the condyles it is much better to use tibial transfixion; only a $\frac{1}{8}$-in. pin is required, and it can be left in place for six to eight weeks without harm. For fractures of the tibia and fibula, especially in the lower third, skeletal traction from the heel is of the utmost value. I know of no kind of footpiece which can hold and give traction for any length of time without damage to the skin. Whether the calcaneum is transfixed or whether the pin is passed above the heel bone is not very important. But if the supra-calcaneal transfixion is used, it is essential that the pin should be firmly fixed to the foot so as to prevent lateral rocking, which by dragging on the soft parts causes great pain and ulceration. The simplest way of securing this fixation of the pin is by a plaster bandage; otherwise it is necessary to use a special footpiece in which a sole-plate is clamped to the ends of the transfixion pin.

One more point is worthy of reference, and that is the great value of skeletal traction for complicated open fractures in the upper limb. In septic fractures of the humerus, particularly at its lower end, the arm is slung by the hand with the elbow at a right angle, whilst the traction is made by a pin through the olecranon. In fractures of the forearm bones steel nails of suitable length should be driven into the lower ends of the radius and ulna, and the arm suspended by a cord loop tied to the projecting heads of these. This will not only produce traction but will also exert a lateral pull on the bones, which counteracts the natural tendency they have to falling in towards one another. Difficult cases of fracture of the metacarpals and phalanges should be treated by traction through a small pin passed right through the base of the terminal phalanx, a stout needle serving this purpose very well.

Space will not permit a detailed discussion of other forms of treatment, but brief reference must be made to two particular methods.

The Plating of Infected Fractures.— It would seem almost unnecessary to mention this to an enlightened audience; but unhappily it is a practice which is only too commonly pursued. The great pioneer of bone-plating always insisted on the necessity of a clean field. In the War the disastrous

results of plating open fractures were proved by repeated tragedies. But still this practice continues, and I cannot allow this opportunity to pass without saying quite deliberately that I regard the plating of an open fracture as a surgical crime. It would seem that the jagged ends of a bone seen in an open wound exercise a sort of fatal fascination upon a certain type of adventurous practitioner who cannot resist the lure of the carpenter's tools. The septic bones are exposed still further, drilled, and screwed—and then the patient will be fortunate if after an extensive necrosis he escapes with his limb and his life.

The Use of Plaster-of-Paris.—In a general way, and until quite recently, I have been accustomed to regard the routine use of plaster-of-Paris in the treatment of open fractures as unjustifiable either in theory or practice. But first by reading Dr. Winnett Orr's writings, and then by meeting him and discussing the matter with him and those who have used his methods, I have been so much impressed by the value of his work that I determined to bring his ideas before this association, and now fortunately we have been able to do even better and bring Dr. Winnett Orr himself to expound his own views. Dr. Winnett Orr's method consists in immediate cleansing of the wound, packing it with sterile vaseline gauze, leaving it wide open, and, having adjusted the fracture, putting up the limb in a plaster case which is not taken off or opened for several weeks unless there is a rise of temperature or other untoward symptoms appear.

I am quite convinced that this method is of great value in special cases, but am not at all clear yet whether it would be wise to suggest it as a routine treatment. Its outstanding merits are that it saves the patient a great deal of suffering and a prolonged stay in hospital. It appears to have three obvious dangers and drawbacks. It is a dangerous method to put into the hands of an inexperienced practitioner. If the wound has been sterilized at the first operation, the leaving a wide open wound to heal by granulation is much less ideal than closing it by delayed primary suture. And, thirdly, it must in many cases tend to make the correct alinement of the fracture faulty, because this has to be controlled by a plaster case, which must become loose as the swelling of the limb goes down. However, perhaps after we have heard Dr. Winnett Orr, these objections may not seem to be so weighty.

NOTE OF A CASE OF INFECTED OPEN FRACTURE TREATED BY DR. WINNETT ORR.

On May 3, before a number of Fellows of the Association of Surgeons at the Bristol General Hospital, Dr. Winnett Orr carried out the treatment of a case which had been under my care. I have been so much impressed with his method and its results in this case than I cannot do better than describe it.

Alfred S., age 55, suffering from an open fracture of the right tibia and fibula caused by a fall from a roof on Feb. 27, 1930.

He was treated by immediate toilet of the wound, which was sutured, and he was put up on a back splint and side-pieces. However, the suturing broke down and a chronic suppuration ensued. Later on the leg was slung on a cradle splint

with pin traction from the calcaneum. After two months his condition had not undergone much change, and the X ray showed some necrosis of both fragments of the tibia, with considerable overlapping (*Fig.* 177). The wound was being dressed daily. The patient was in this condition when Dr. Orr saw him and operated upon him. He already had a pin through the os calcis. By means of this the foot was held firmly in the footpiece of a Hawley's table and sufficient traction applied to pull the leg out to a little more than its normal length.

FIG. 177.—Skiagram of leg two months after accident, showing bad position and necrosis.

OPERATION.—The wound, which before treatment had the appearance shown in *Figs.* 178, 179, was now excised and curetted. The overlapping bone fragments were chiselled away so as to leave a funnel-shaped cavity leading down to the deep surface of the

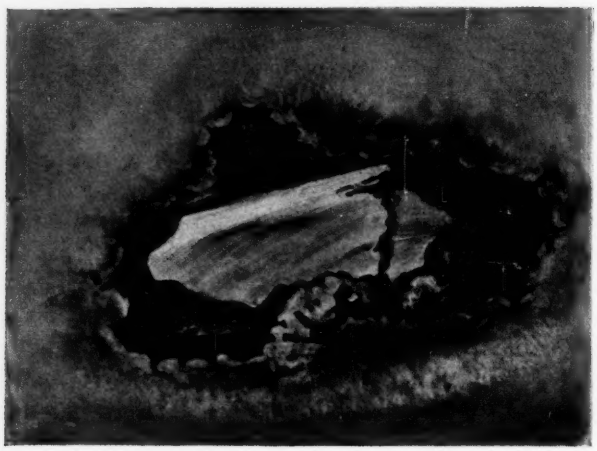

FIG. 178.—Condition of wound on May 3, 1930, just previous to treatment by Dr. Orr.

tibia. A few small necrosed fragments were removed. Although the bone had been drawn out to rather more than the full length, considerable lateral displacement still persisted. This was corrected and maintained by means of a long

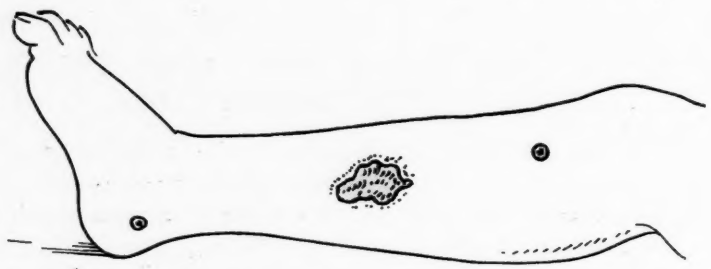

FIG. 179.—Diagram of relative size and position of wound and the sites of transfixion.

transfixion pin which emerged obliquely from the front of the wound. The wound, which had bled very freely, was packed first with dry gauze, then with iodine, and after with spirit. The bleeding was thus controlled, and into the dry cavity gauze impregnated with vaseline was packed firmly until it reached the surface.

Over the surface another vaseline pad was placed, and then a thin layer of cotton-wool. A long transfixion pin was passed through the crest of the tibia just below the tubercle. A plaster-of-Paris case was put on the leg so as to include the three transfixion pins, and extending to the lower third of the thigh. The patient was returned to bed upon an open-air balcony.

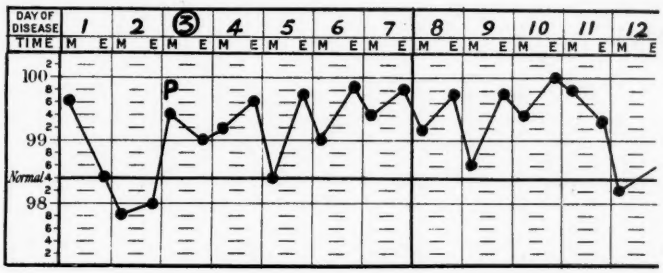

FIG. 180.—Temperature chart. P, Winnett Orr operation; plaster applied.

SUBSEQUENT PROGRESS.—This very drastic treatment has been followed by a perfectly smooth recovery. The man had a certain amount of pain and rise of temperature for the few days following the operation (*Fig.* 180). The pin which fixed the site of the fracture was removed after three weeks, and the other two pins a fortnight later. After the first week the plaster, which was deeply stained with blood, became rather odorous, and this continued all the time until its removal. The smell was not very objectionable in this case because the man was all the time on an open-air balcony, but it would have been much more unpleasant if he had been in a closed ward. (*Figs.* 181, 182.)

Eight weeks after it had been applied the plaster was cut off. The condition of the limb was very remarkable. All over the front of the leg was a mound of vaseline gauze mixed with stale blood and pus, and smelling very disagreeably. But on cleaning away this mess a small healthy granulating wound was found on which were a few minute bone fragments (*Fig.* 183). The limb was re-sterilized, the wound covered with a vaseline pad and again put up in plaster, below the knee but including the foot, for five weeks, the patient being allowed to walk with crutches. The X ray showed that union had taken place (*Fig.* 184). The man is now (Aug. 20, 1930) walking with side-irons from the knee to the shoe, and has good movement in both knee and ankle.

FIG. 181.—Skiagram after treatment, showing pins in the tibia.

To me this case has afforded a most convincing demonstration of the value of Orr's method. It has made good the claim of its author of greatly

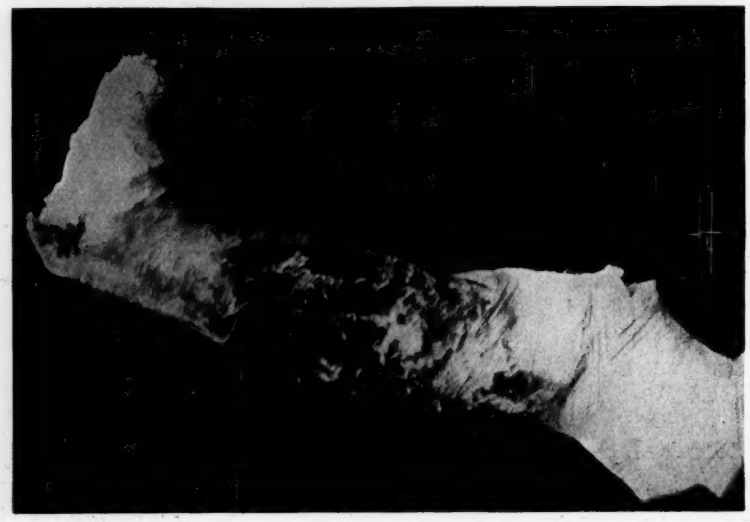

FIG. 182.—Photograph of the limb in plaster, which was not changed for eight weeks.

simplifying the after-treatment. During thirteen weeks the patient was dressed only twice instead of the ninety-one times which the general routine of a daily dressing would have involved. But much more than this, the limb was restored to its full length with good alinement even in a case in which primary treatment had failed and chronic sepsis had been firmly established.

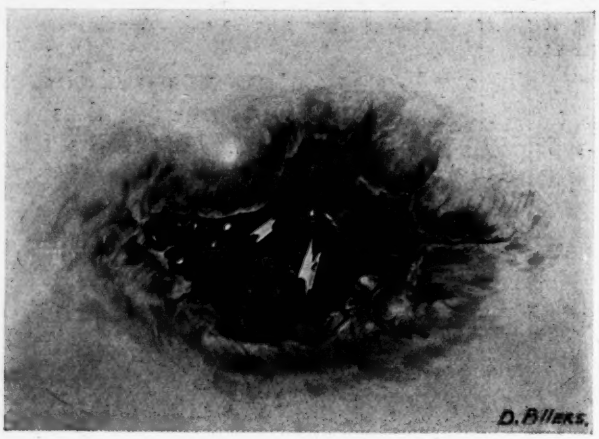

FIG. 183.—Appearance of the wound eight weeks after treatment on removal of the first dressing.

FIG. 184.—Skiagram of leg eight weeks after treatment. Note good union and position.

AN OPERATION FOR THE COMPLETE EXPOSURE OF THE ELBOW-JOINT.

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Exposures of the elbow-joint for the excision of tuberculous joints and severe open fractures by the classical methods associated with the names of Langenbeck, Kocher, and Cheyne are adequate for the remedy of the destructive lesions for which these great surgeons designed them. For more delicate

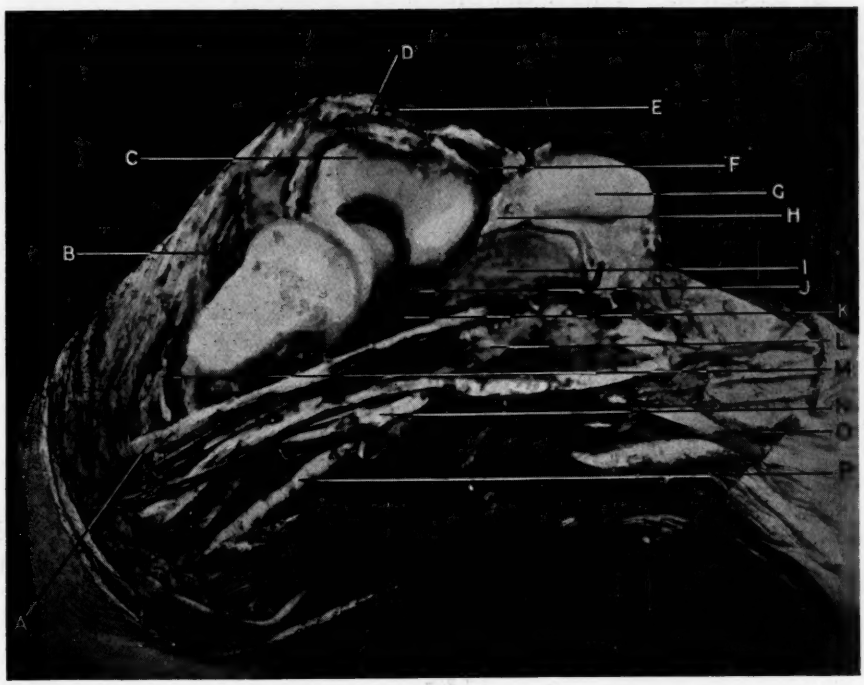

Fig. 185.—Anatomy of the elbow-joint. A, Ulnar nerve; B, Triceps; C, Olecranon, trochlear surface; D, Capsule; E, Flexor carpi ulnaris (olecranon head); F, Pronator teres (deep head); G, Epicondyle; H, Internal lateral ligament (cut); I, Pronator radii teres; J, Brachialis anticus; K, Nerve to pronator teres (median); L, Superficial veins; M, Anastomotica magna; N, Median nerve; O, Palmaris longus; P, Brachial artery. In this dissection the internal lateral ligament was cut through. This is not necessary in order to expose the joint.

operations, such as the removal of loose bodies, arthroplasty, and the operative repair of intra-articular fractures, the classical routes are somewhat too destructive, in that muscles are extensively stripped from their bony attachments, and complete exposure is only attained after the removal of parts of

the articulation. Limited arthrotomies (1) above the head of the radius, (2) by division of the olecranon process and its subsequent fixation with a screw, make it difficult to inspect the whole joint, in that the nature of the joint hinders a ready transference of vision and manipulation from the front to the back of the joint, and vice versa.

The operation to be described was suggested by experience with a patient who sustained a backward dislocation of the elbow, fracture of the internal epicondyle, and complete division of the ulnar nerve. The epicondyle was displaced within the joint, whither it had carried the proximal end of the ulnar nerve, and there was outward dislocation as a consequence.

Exposure of the ulnar nerve by the method suggested by Mr. Harry Platt discovered an open joint, and it was apparent that but a few touches with the knife were needed to dislocate the joint, or rather to open it on its inner side.

Anatomy (*Fig.* 185).—The key to the anatomy of the inner side of the elbow is the epicondyle with the group of muscles attached to it, and with the strong band of the internal lateral ligament which runs from the epicondyle to the coronoid process of the ulna. These muscles — flexor carpi ulnaris (humeral head), flexor sublimis digitorum, palmaris longus, flexor carpi radialis, and pronator radii teres (humeral head)—strengthen the joint on its inner side. Neither the muscles nor their nerve-supply are compromised by detaching the internal epicondyle. The joint surfaces are not damaged by this manœuvre, and the detachment is one which lends itself to repair. The ulnar nerve is in danger on this side of the joint, but by making it a landmark, by clearing it and its branches through the extent of the field of operation, and by transplanting it to the forearm, it is safer than in the Langenbeck operation.

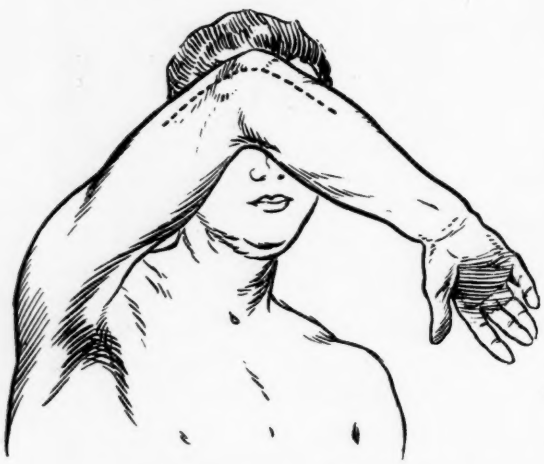

FIG. 186.—Position of arm and line of incision.

The median nerve is not exposed normally; if it is required for inspection, it may readily be found lying on the anterior surface of the brachialis anticus, or between the heads of origin of the pronator radii teres. Important blood-vessels are not encountered; the anastomotica magna branch of the brachial may be seen in the upper part of the incision in close contact with the brachialis anticus muscle. The posterior ulnar recurrent lies in the groove behind the internal condyle, where it is readily controlled. The anterior ulnar recurrent lies in close relation to the brachialis muscle, and is turned aside with that structure.

The Operation (*Figs.* 186–190).—The forearm is acutely flexed and fully

pronated ; the elbow is raised, and rotated so that the inner side of the joint presents towards the surgeon standing on the side of the arm to be explored, and the outer side towards the patient's head. The incision follows the line of the ulnar nerve about four inches in the forearm and four inches in the upper arm (Platt) (*Fig.* 186). The ulnar nerve is sought in the arm just behind the internal intermuscular septum, and between that structure and the inner head of the triceps. It is gently freed as far as the groove behind the inner epicondyle. The space between the humeral and olecranon heads of the flexor carpi ulnaris is next sought, and these heads are separated ; this discloses the nerve in the forearm. The branches to the muscle are mobilized and preserved ; the branch to the joint given off behind the epicondyle is sacrificed. The fascia over the nerve in the groove is divided and the nerve is displaced into the forearm.

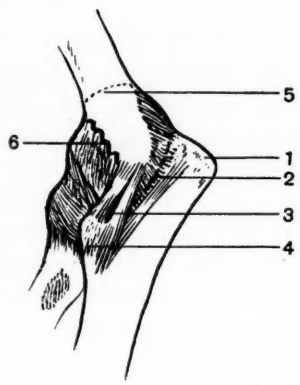

FIG. 187.—1, Insertion of triceps; 2, Incision in capsule; 3, Strong ligament, which is preserved; 4, Insertion of brachialis anticus; 5, Line of emergence of osteotome; 6, Line of detachment of capsule.

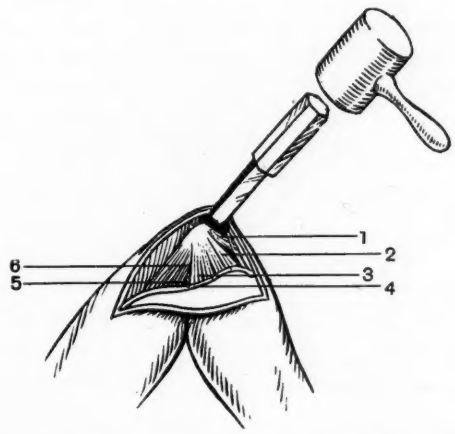

FIG. 188.—1, Anterior fibres of the internal lateral ligament; 2, Flexor carpi ulnaris (humeral head); 3, Pronator radii teres (humeral head); 4, Ulnar nerve; 5, Median nerve; 6, Internal intermuscular septum.

To this point the operation is that attributed to Stiles, and described by Mr. Harry Platt. The outline of the trochlea seen through the capsule is the next landmark, and the joint is opened by a short incision to the inner side of this process (*Fig.* 187). The incision is placed so as to be parallel to and behind the ligamentous fibres which run from the epicondyle to the inner margin of the coronoid process. Through this incision an osteotome is introduced (*Fig.* 188), pressed against the under surface of the epicondyle where it abuts on to the inner non-articular face of the trochlea, and the epicondyle is divided in an upward direction. (It is of advantage to drill a hole through the epicondyle from its tip upwards, outwards, and slightly forwards, to take the screw, before detaching this process.)

Next, find the outer border of the pronator radii teres, and clean this as far as the epicondyle, where a few fibres arise from the internal intermuscular septum, taking care not to injure the long twig from the median nerve which enters the deep surface of this muscle. Detach the internal intermuscular septum from the epicondyle, and turn the common flexor origin downwards towards the forearm. (Should it be desired to see the median nerve, it may

be sought in the interval between the humeral and ulnar heads of the pronator radii where it enters the forearm; the twig to the pronator leaves the trunk of the nerve at a higher level, and must be preserved.

FIG. 189.—Diagrams showing extent of detachment for complete exposure. For exposures on the inner side less is necessary. The attachment of the external lateral ligament is preserved in all cases.

Returning to the joint, a sharp rugine readily detaches the posterior fibres of the capsular ligament from the margin of the olecranon fossa (*Fig.* 189). If in this manipulation the operator keeps close to the bone, the posterior communicating branch of the anastomotica magna artery is not encountered; it crosses about three-quarters of an inch above the attachment. The communication with the posterior ulnar recurrent artery will be severed, and needs a ligature at each end.

Retract the muscles to the flexor side of the internal intermuscular septum; the brachialis anticus and biceps with the median nerve and the brachial artery are all included in this retractor, the last three being seen only if the brachialis is cleaned rather more than is necessary. With a rugine detach the anterior capsular fibres of the joint from the coronoid fossa after the elbow has been somewhat extended. The joint is now free to the inner side, in front, and

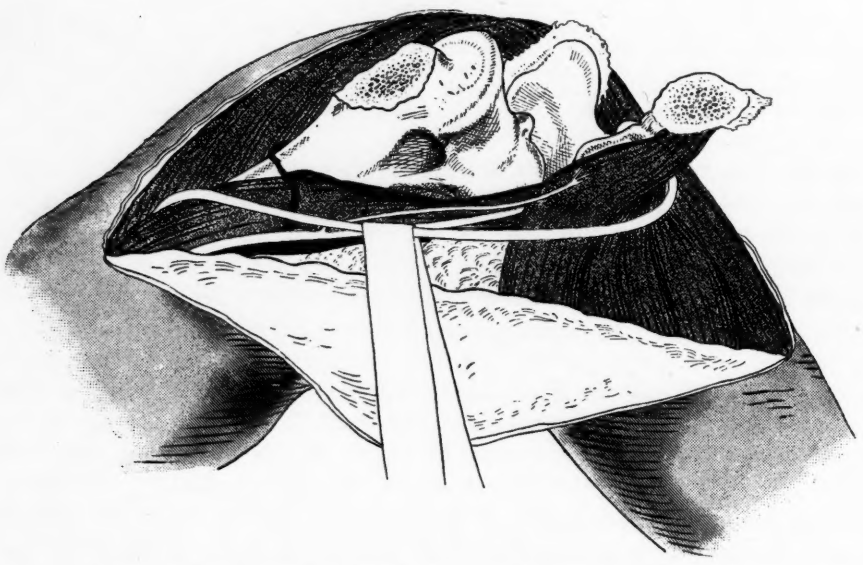

FIG. 190.—Diagram to show the extent of the exposure obtained.

behind; all that is needed is to flex the forearm to a right angle and strongly over-pronate it. The whole of the lower end of the humerus is

exposed to view, and the whole of the sigmoid fossæ on the olecranon, and with a little retraction the head of the radius and the semilunar synovial folds between this and the capitellum are also exposed (*Fig.* 190).

When the intra-articular manipulations are completed, the forearm is supinated to re-engage the joint surfaces. The epicondyle is fixed in its original position with a screw about an inch and a quarter long. A few points of suture unite the triceps to the brachialis, including in their bite the intermuscular septum; the short incision in the capsule is closed, and the ulnar nerve is secured under the deep fascia of the forearm in an incision made to receive it. As an alternative method of disposing of the ulnar nerve, it may be placed with the median nerve between the two heads of the pronator radii teres, and in front of the epicondyle.

It is suggested that this operation, which is easily executed in practice, will prove of service in a search for loose bodies and fragments of bone, that repair of T-shaped and other articular fractures will be facilitated, that arthroplasty with preservation of the strong lateral ligaments may be expected to yield a stable joint, and that it lends itself to the exposure of those complicated injuries involving bone, joint, and nerves met with in this situation.

HÆMANGIOMA OF THE KIDNEY.

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Hæmangioma of the kidney is of relatively rare occurrence, and authors of wide experience frequently report only a single new case. Infrequent though it may be, it is a condition of surgical importance, for it appears that a large proportion of cases ultimately demand operation more or less urgently. In the cases published an accurate pre-operative diagnosis has seldom been made. It seems desirable, therefore, to record a further case, in which sudden and severe hæmaturia necessitated immediate operation, the orgin of the bleeding being a cavernous hæmangioma. In view of the difficulty experienced in distinguishing in the literature true angiomatous tumours from other lesions causing hæmaturia, an attempt has been made to review and classify the cases previously reported.

CASE REPORT.

History.—Miss A. M., age 61, had an attack of pain in the right lumbar region on March 13, 1929. This was of a dull, aching character and increased steadily in severity. On the following day she had a profuse hæmaturia accompanied by typical renal colic and the passage of worm-like clots. Attacks continued for the next four days, at the end of which X-ray plates of the right kidney region were taken, without revealing stone. She was seen by Mr. Roy F. Young on March 18, when severe hæmaturia was still present. The general health was good, and symptoms of renal disease had never previously been observed.

Fig. 191.—The pelvis and the visible minor calices are of normal appearance, but the lowest group of minor calices is not seen.

On Examination.—The patient was healthy in appearance. Some tenderness in the right lumbar region was the only sign of renal involvement; no enlargement of the kidney could be detected. The urine was acid and heavily mingled with blood.

Cystoscopy (March 18).—The bladder and ureteric orifices were healthy. There was profuse bleeding from the right ureter; the urine from the left ureter was free from blood. Intravenous indigo-carmine appeared from the left ureter in just under five minutes.

X-ray Examination (March 18).—A pyelogram of the right kidney (*Fig.* 191) showed a filling defect of the inferior calix major and related minor calices.

Pre-operative Diagnosis.—Tumour of the lower pole of the right kidney.

Operation (March 21—Mr. Roy Young).—The right kidney was exposed by

a loin incision. The organ was not enlarged. There was no external evidence of tumour, nor of any growth along the blood-vessels. Nephrectomy was performed, however, because of the dangerous hæmaturia and the abnormal pyelogram.

SUBSEQUENT PROGRESS.—Convalescence was uncomplicated. For five days after operation the amount of urine passed in twenty-four hours averaged about 20 oz. On the sixth day it increased to 54 oz., and thereafter the output was maintained at about this figure.

The kidney was bisected; one half, of which a drawing is shown (*Fig.* 192), was mounted as a museum specimen; the rest was utilized for histological examination.

MORBID ANATOMY.—The kidney is of normal size and shape. The large superior pyramid shows striate congestion, but otherwise the parenchyma is not obviously abnormal. A striking feature of the sectioned kidney is a circular mass of blood-clot, distending and firmly adherent to one of the uppermost of the lower group of minor calices, compressing an adjacent minor calix and also the opening of the inferior calix major, thereby producing the filling defect seen in the pyelogram. Directly above this mass of clot, in the wall of the pelvis at the opening of the superior major calix, is an area of tissue of cavernous appearance, semilunar in section, but extending round the lower wall of the superior calix major, and in the adjacent minor calices of the inferior group, as far as the angle of deviation. This tissue constitutes the angioma. Much hæmorrhage is present in the inner layers of the pelvis, the inferior calix major, and the majority of the minor calices near the angle of deviation. The tissues of the hilum contain much blood, and the gross features suggest the presence of multiple foci of angiomatous tissue, but, as described below, these appearances are due to widespread hæmorrhages.

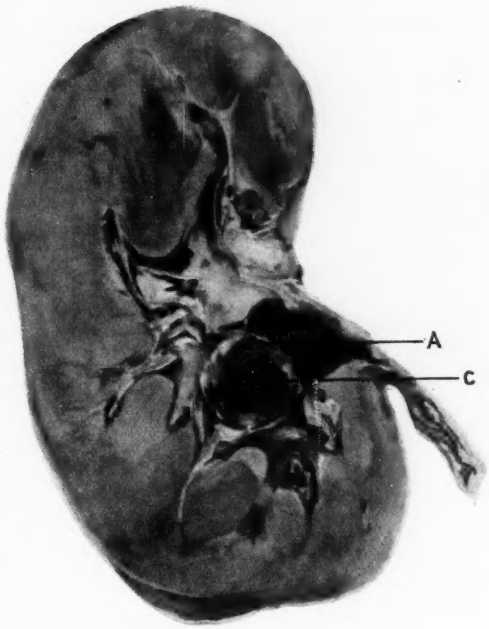

FIG. 192.—The bisected kidney. The angioma, semilunar in section, is seen at A. The opening of the inferior calix major is obstructed by the presence in an adjacent minor calix of a spherical mass of blood-clot, C. There is extensive hæmorrhage in the wall of the pelvis and several minor calices.

FIG. 193.—The angioma. The growth is seen to occupy the wall of the minor calix and to extend for a short distance along the interlobular septum. (× 7.)

Microscopic Examination.—The low-power photomicrograph (*Fig.* 193) shows clearly the situation of the angioma in the renal pelvis. The portion represented is the wall of one of the minor calices in the region of the angle of deviation. Angiomatous tissue is present in the wall of the calix, and extends for a short distance into the kidney substance along the interlobular septum.

FIG. 194.—A portion of the angioma. Thin-walled blood-spaces of varying size, lined by flat endothelium and separated by septa of delicate fibrous tissue. Fairly numerous eosinophil leucocytes are present in the stroma. (× 130.)

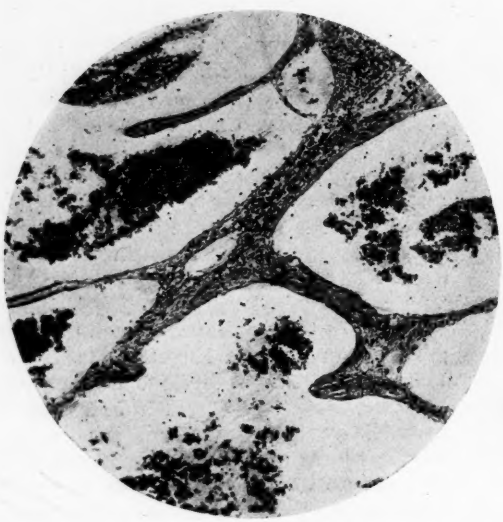

FIG. 195.—A portion of the angioma. Note the thin-walled blood-spaces and absence of hyperplasia of the endothelium. (× 50.)

The cavernous tissue (*Figs.* 194, 195) consists of wide blood-spaces, lined by flattened endothelium, nowhere hyperplastic, and separated by fibrous septa, some very delicate, others thicker and containing a few smooth-muscle fibres. Numerous eosinophil leucocytes are present. In certain areas thrombosis has occurred and organization is in progress. Several of the blood-spaces near the angle of deviation which abut upon the renal pelvis have ruptured, and free communication has been established between the sinuses of the angioma and the minor calix, which is filled with blood-clot (*Fig.* 196). This lesion is the source of the hæmaturia.

The cavernous tissue is separated from the renal parenchyma by an area of young fibrous tissue which contains numerous capillary

blood-vessels lined by plump endothelial cells and is overrun by eosinophil leucocytes. No transition is found between the vessels of embryonic type and the wide spaces of the angioma. The tissue separating the cavernous spaces from the renal parenchyma is thus a sort of young granulation tissue, which for some

FIG. 196.—The lesion determining hæmaturia. Certain of the large blood-spaces have ruptured and communicate freely with the pelvis, which is filled with blood-clot. The remains of the walls of the spaces are seen ending freely in the cavity of the calix. (× 25.)

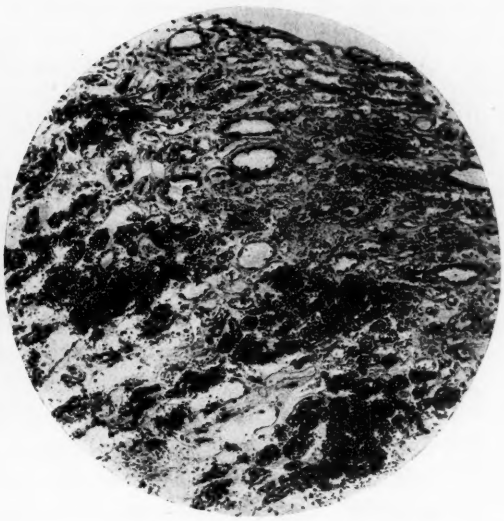

FIG. 197.—The inflamed papilla. The intertubular vessels are extremely engorged. Many of the tubules have lost their epithelial lining, while others show swelling and regenerative changes in the epithelium. (× 50.)

distance extends along the septa accompanying the interlobular vessels into the renal substance. There is some catarrh in the adjacent tubules and glomeruli, and casts or blood-corpuscles are present in the lumina of the tubules.

The pyramid entering the calix which is distended by blood-clot shows recent acute inflammatory change. There is some necrosis at the tip, leucocytic emigration, extreme engorgement of the intertubular veins, and desquamation of the tubular epithelium. At their termination the ducts of Bellini are devoid of epithelium and contain masses of granular débris and leucocytes, while at higher levels reparative processes with active proliferation of epithelium are in progress (*Fig.* 197).

The pelvic wall is œdematous and shows extensive subepithelial hæmorrhage (*Fig.* 198). A few large thin-walled vessels can still be distinguished, and these show margination

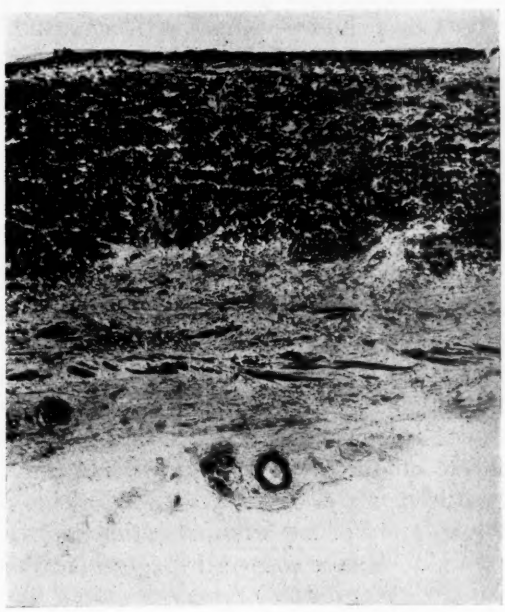

FIG. 198.—The wall of the renal pelvis. There is very extensive subepithelial hæmorrhage. (× 20.)

of the leucocytes, while at places there is marked perivascular infiltration of lymphocytes and mononuclear cells.

As mentioned previously, the fibro-fatty tissue of the hilum filling the spaces between the minor calices contained much blood, and the appearances suggested that there might be many scattered foci of angiomatous tissue in these situations. Microscopic examination, however, reveals no such structure, and the appearances are due solely to the presence of numerous small hæmorrhages.

With the exception of the papilla entering that calix which is filled by blood-clot, and the tubules and glomeruli close to the granulation tissue extending from the angioma into the kidney substance, the renal parenchyma is healthy.

DISCUSSION.

The morbid appearances described are of considerable complexity. The kidney shows three lesions, each of which may be associated with hæmaturia: (1) An angioma of the renal pelvis; (2) Extensive hæmorrhage in the sub-epithelial tissue of the renal pelvis; (3) A condition of papillitis with extreme vascular engorgement in the renal pyramid entering the calix, which is filled with blood-clot.

With regard to the second and third lesions, Quinby (1920) has stated that subepithelial pelvic hæmorrhage, together with a degree of congestion of the renal pyramids, may be the sole lesion present in so-called 'essential hæmaturia', as in two cases which he published. This has been the significant finding in eight similar cases which have come under the present author's notice. In the case now reported, however, the angioma of the pelvis is clearly the primary lesion. The subepithelial hæmorrhage has spread from the neighbourhood of the tumour, and the condition of papillitis has been determined by the presence in the related calix of a mass of clot derived from hæmorrhage from the ruptured angioma and firmly attached to it.

The primary lesion is a cavernous structure composed of thin-walled blood-spaces lined by flattened endothelium in no wise hyperplastic. Its margins show no evidence of infiltration or spread of a neoplastic process. The microscopic findings resemble those frequently met with in cavernous angiomata of the liver.

The origin and exact nature of angiomata is obscure. Some authors (Borst, 1923, et al.) apply to them the term 'hamartoma', used by Albrecht (1904) to designate neoplasms arising in developmental error and showing "lack of proliferation of their cells, absence of tendency to expansion or destructive infiltration, and the maintenance of the function of the constituent cells." Borst suggests that the mechanism of production of angiomata lies in local failure of development of the proper tissue—of skin, liver, kidney, etc.—with compensatory overgrowth of vascular mesenchyme.

The cutaneous nævi, being of course the most accessible, have been the most completely studied. Practically always congenital, and frequently multiple, they occur particularly in the region of the embryonal fissures, where rests of superfluous embryonic tissue are most likely to occur. Angiomata, however, show all stages of differentiation. The cirsoid aneurysm is a simple overgrowth of a segment of the arterial tree, approaching closely in structure to normal adult blood-vessels. The ordinary congenital nævus shows a degree of anaplasia toward the embryonic type of blood-vessel and

a certain capacity for progressive growth and local malignancy. Finally, rare cases of metastasizing angiomata are on record in which death was caused by systemic dissemination of a cellular tumour composed of endothelial cells forming irregular capillary spaces (Ewing, 1918). Borst quotes from Kahle the occurrence in malignant angiomata of hæmopoiesis, a return to embryonic activity.

While many angiomata come under observation at a non-progressive stage, yet a period of growth in post-uterine life must often have preceded. Capillary nævi frequently enlarge, and they may also alter in type, showing cavernous transformation centrally, while growth may continue for a variable period in the peripheral zone of sprouting capillary buds. As Virchow (1867) pointed out, such changes may occur early, or they may arise late in life in capillary nævi long quiescent.

It is reasonable to assume that visceral angiomata may follow a similar course and that a tumour in such a situation as the kidney may therefore produce symptoms early or after a long period of latency. On the other hand, a tumour originally of cellular capillary type may become cavernous in structure, may develop a capsule, and ultimately lose all signs of active growth.

The term 'hamartoma' as applied to these tumours is of value in emphasizing, with regard to their genesis, the greater importance of developmental error than of extraneous stimulus. Precisely as in other tissues, however, the neoplastic lesions of blood-vessels form a continuous series from the most benign to the most malignant, and it does not appear to be of value to segregate the small group which conforms completely with Albrecht's definition.

The further point remains as to the possible relationship between such vascular tumours and chronic inflammatory processes. Ewing has stated that a definite relation between chronic granulation tissue and any of the characteristic vascular tumours can rarely be established. In the present case there is around the tumour a zone of tissue the seat of mild chronic inflammation and showing new formation of blood-vessels. It is probable that this represents merely a reaction of the surrounding tissues to the tumour mass.

REVIEW OF THE LITERATURE.

Virchow states that, with the exception of the liver, the kidney is the organ most frequently the seat of angioma, and that the latter is of not uncommon occurrence; but it is difficult to obtain confirmatory evidence of this from the writings of others. Thus Fukuda (1911) describes two angiomata of the renal parenchyma discovered accidentally at autopsy. He regards them as of great rarity. Kaufmann (1922), without giving details, states that they are rare, and Professor Muir informs me that he can recall no example of renal angioma found post mortem at the Western Infirmary. It must be admitted, however, that without purposeful search and microscopic examination small angiomata might be overlooked, or mistaken for foci of hæmorrhage.

From the literature 17 cases of renal angioma have been collected, but

all of these caused bleeding sufficiently severe to necessitate surgical treatment. They have been classified in order to determine whether any constantly recurring clinical feature might be of service in the differential diagnosis of cases of hæmaturia.

1. **Angiomata of the Renal Pelvic Wall.** — Six additional examples of angioma of the renal pelvis resembling that described have been found in the literature (*Table I*). The symptoms are very variable. Hæmaturia may be

Table I.—Angiomata Arising in the Wall of the Renal Pelvis.

Author	Age	Sex	Side	Symptoms	Nature of Lesion
Swan (1921)	19	M.	L.	Profuse hæmaturia for 3 days after football. Urgent	Cavernous angioma close to pelvis
Kidd (1924)	19	M.	R.	Attacks of hæmaturia with fainting, retention, etc., 10 years. Finally urgent	Dilated sinus-like spaces below epithelium of calix
Suter (1902) from Lutz (1925)	32	F.	—	Progressive hæmaturia 1½ years	Multiple pelvic angiomata
Jenkins and Drennan (1928)	33	F.	L.	Two previous attacks in 8 years; severe hæmaturia 1 week	Closely packed thin-walled vessels under epithelium of calix
Wheeler (1924)	37	M.	L.	Severe uncontrollable renal hæmorrhage without previous warning. No pain or tenderness	Angiomatous formation under epithelium of 3rd uppermost calix. Also a cluster of vessels under capsule
Author's case	61	F.	R.	Pain and severe hæmaturia 8 days. Urgent	Angioma of wall of pelvis
Lutz (1925)	62	M.	L.	Pain and hæmaturia 5 weeks	Loose cavernous tissue immediately under epithelium of calix

so severe and dramatic in its onset that immediate nephrectomy may be necessary to save life, or less severe attacks of hæmaturia may occur over a period of years. But it is fairly clearly brought out that in most cases the symptoms of a lesion of this type tend to run an acute course and rapidly to reach a stage when intervention of some sort is imperative.

The case of Jenkins and Drennan (1928) showed, in relation to an upper calix, an angiomatous growth one inch in diameter which had produced in an adjacent pyramid—apparently by pressure—necrosis, hæmorrhage, and desquamation, changes closely resembling those in the case submitted. These authors describe a mottled appearance in the pyelogram, and they compare this with the mottled appearance described by Jacobs and Rosenberg (1927), as is mentioned later. They suggest that this sign may be of diagnostic importance. In Swan's case (1921) hæmaturia originated after a game of football, and was so severe as to necessitate nephrectomy after three days.

Lutz (1925) describes the case of a male subject of 62 years who suffered from severe hæmaturia of five weeks' duration due to a pelvic angioma. He discusses the classification and the pathogenesis of such lesions. He regards all as congenital abnormalities due to local failure of development of the renal rudiment and ingrowth of excess of vascular mesenchyme. This may form a progressive tumour or it may be latent until the later years of life, when degenerative changes and increased blood-pressure, causing general or local passive congestion, may lead secondarily to widening of the vascular spaces so as ultimately to produce symptoms. In support of the congenital origin of these tumours he also quotes the case of Suter (1902) in which hypoplasia of the kidney and pelvis was associated with multiple pelvic angiomata. Wheeler (1924) illustrates the dramatic suddenness with which dangerous hæmorrhage may occur apart from predisposing trauma and without pain or tenderness or previous warning hæmorrhage.

2. **Angiomata of the Renal Cortex.**— Virchow states that angiomata of the kidney occur most frequently immediately under the capsule and that they may be multiple. From the literature only four such cases giving rise to symptoms have been collected (*Table II*). In these cases the tumour had attained to a relatively large size, yet in none did the bleeding constitute a surgical emergency.

Table II.—Angiomata of the Renal Cortex.

Author	Age	Sex	Side	Symptoms	Nature of Lesion
Gile (1929)	37	M.	R.	Hæmaturia 9 months ..	Cavernous tumour (6 × 6 in.)
Judd and Simon (1928)	57	F.	L.	Hæmaturia 20 years ..	Tumour upper pole (1·5 × 2·5 cm.)
Deansley, quoted by Swan (1921)	66	M.	L.	Hæmaturia 6 months ..	Multiple capillary angiomata of cortex. One removed—recovery
McKenzie and Parkin (1929)	—	—	L.	Hæmaturia 2 weeks ..	Large angioma, upper pole

3. **Angiomata of the Renal Pyramids.**— The remaining 7 cases consist of angiomata of the pyramids, and of these full information is available in 6 (*Table III*). The subjects range in age from 23 to 54. In none was emergency surgery necessary.

The case of Jacobs and Rosenberg (1927) is inserted in this series with some hesitation. These authors describe the lesion which they report as a telangiectasis or hæmangioma simplex, involving the upper pole of a kidney, particularly certain pyramids and the wall of the pelvis, and they differentiate it sharply from the cavernous hæmangiomata published by other writers. In doing so they imply that the other recorded cases exhibit histological evidence of potentiality for progressive neoplasia. A survey of the literature, however,

does not convey the impression that the majority of vascular tumours of the kidney show hyperplastic endothelium or evidence of progressive growth. The reasons which led to the adoption of the title 'cavernous hæmangioma' in our case might justifiably support the inclusion of this last in the same group. Jacobs and Rosenberg describe a mottled appearance seen in the pyelogram, and suggest that it may be due to entry into the blood-spaces of the lesion of the pyelographic shadow-producing medium, and that this appearance may be of some diagnostic value.

Table III.—Angiomata of the Pyramids.

Author	Age	Sex	Side	Symptoms	Nature of Lesion
Morris (1901)	23	F.	L.	Severe hæmaturia and pain in loins for some years	Multiple angiomata of pyramids
Stieda (1923)	29	M.	R.	6½ years' progressive hæmaturia	Angioma of pyramid with calcification of stroma
Simpson (1927)	30	F.	R.	18 months' progressive hæmaturia	Angioma size of pin-head at papilla-tip
Begg (1926)	33	M.	R.	Hæmaturia 2 years previously after strain; recurring recently after another strain	Blood cyst of lower pole originating in angioma of a lower pyramid, and cutting off lower calix major
Jacobs and Rosenberg (1927)	36	F.	L.	Backache and hæmaturia 4 weeks. Mottling in pyelogram	Extensive telangiectasis of an upper pole and also of the renal pelvis
Newman (1915)	54	M.	L.	Hæmaturia 4 years ..	Angioma of uppermost pyramid. Encapsulated
Rousing (1918) from Lutz (1925)	—	—	—	Sharp bleeding	Angioma size of pea replacing renal papilla

Begg (1926) states that hæmaturia was twice precipitated by a 'strain' in his case, which showed a blood cyst, 11 cm. in diameter, of the lower pole of the right kidney, arising apparently in a cavernous angioma and communicating with the pelvis. Morris (1901) describes multiple angiomata in a male subject who died of septicæmia, after having survived many attacks of hæmaturia. Stieda (1923) quotes a case in which the external appearance of the kidney was perfectly normal, and at the first operation decapsulation only was performed. Hæmorrhage continued, and nephrectomy was necessary later. The kidney contained an angioma of a pyramid. He discusses the causal inter-relation between calcification of the papillary stroma and the angiomatous formation, and also the connection of exposure to cold and overstrain with the occurrence of hæmaturia.

FACTORS DETERMINING HÆMATURIA FROM RENAL ANGIOMATA.

The total number of recorded cases is too small, and the individual details are too diverse, to permit the drawing of wide conclusions. The majority of the cases have been discovered through severe hæmaturia necessitating surgical intervention. Renal angiomata appear to have an especial tendency, not shared by angiomata in other situations, to give rise to hæmorrhage. Three factors may contribute to this property: (1) The situation and structure of the tumour; (2) The liability of the tumour to sustain injury; (3) The possibility of obstruction of the venous return from the tumour.

Tumours of the renal pelvis or pyramids are in direct relationship with the pelvis, while those of the renal cortex, at first latent, may grow until they also abut upon the pelvis. The tumour is generally of cavernous type, and the thin-walled blood-spaces covered by only a thin layer of soft pelvic or renal tissue are relatively easily damaged. It is clear how severe trauma or strain, as in the cases of Begg and Swan, may lead to hæmorrhage from such a tumour, but even in the absence of such definite trauma the anatomical structure and relations of the kidney and its physiological excursion during respiration may be factors of importance. The kidney is not firmly anchored to the posterior abdominal wall, but lies in a loose fibro-fatty capsule which allows it to move with the respiratory excursions of the diaphragm and with movements of the trunk. While angiomata of the renal parenchyma are protected, these movements must impose a certain shearing stress upon tumours of the pelvis. Furthermore, the pelvic wall is continually contracting and relaxing as it expels the accumulating urine, and this also will subject the delicate tumours to strain. Finally, if hæmorrhage should supervene, the blood is rapidly washed away by the urine and clotting is not permitted.

Passive congestion also appears to be an important etiological factor, and it has received much attention in the literature. The kidney, as described above, is mobile within limits, yet its vessels are short, straight, and firmly anchored at their origins, and the veins join the inferior vena cava at right angles. Newman (1907) states that the vascular torsion occurring in a preternaturally mobile but otherwise healthy kidney may lead to severe hæmaturia. Hence we may suppose that in the presence of an angioma a less extreme degree of mobility may precipitate hæmorrhage. Lutz emphasizes the importance of passive congestion in producing engorgement, enlargement, and finally rupture of a congenital angioma long latent.

Newman (1914) collected a series of thirteen cases of varix of the renal papilla. These were not apparently true angiomata, but engorgements of the pre-existing veins of the papilla, with a tendency to hæmorrhage. He suggests that vascular obstruction at the boundary zone is the primary cause of the congestion, and quotes good results from nephrotomy, down to the boundary zone, performed roughly in order to produce the maximum of damage to the vascular arches. He states that this treatment diminishes the arterial supply to the papillæ and so relieves the engorged venules. Payne and MacNider (1916), in a series of cases of unilateral symptomless hæmaturia, found that areas of chronic nephritis with fibrosis, occurring at the bases of the pyramids

and at the boundary zone, had caused varicosity and rupture of the veins of the related pyramids. They succeeded in producing similar lesions experimentally in dogs. Extensive nephrotomy relieved symptoms in their eleven human cases. These authors regard nephrotomy as a method of treatment of choice, since it will reveal the presence of other more serious lesions, and in the absence of the latter will lead to cure in a large proportion of cases. Of Newman's cases, complete information is available in twelve. Of these, the varix was in the left kidney in nine. This is suggestive, in view of the longer course of the left renal vein, which also crosses the front of the aorta and might therefore be expected to suffer more frequently from obstruction than the right.

A combination of the three factors described may endow angioma of the renal pelvis with its especial tendency to sudden severe hæmorrhage.

DIAGNOSIS.

The diagnosis of renal angioma is difficult, and the rarity of the lesion is a further handicap. In the past the diagnosis has generally been made by the pathologist. Careful clinical investigation and exclusion of other causes of hæmaturia may establish a state of reasonable probability, but more we can hardly expect.

Simple rest in bed will relieve and therefore eliminate hæmorrhage due to congestion of a prolapsed preternaturally mobile kidney, but it will tend also to alleviate bleeding from other more serious conditions. The urine should be investigated for the presence of tubercle bacilli or other organisms and for the presence of pus cells and casts. Negative findings will help to exclude tubercle and other infections, and the absence of casts will lessen the probability of hæmorrhagic nephritis. The exclusion of this last will be supported if the complaints of the patient and cystoscopic examination demonstrate unilateral renal hæmaturia. X-ray examination will yield negative more often than positive information, and it must be in rare cases only that a diagnostic picture such as that described by Jacobs and Rosenberg and Jenkins and Drennan will be obtained. In fact it seems more probable that the presence of blood-clot in the renal pelvis may produce a filling defect and support an error of diagnosis, as in our case, in which the pyelographic appearances suggest pressure by a tumour upon the lower group of calices. Nevertheless we may exclude renal stone, and it is improbable that a normal pyelogram will be obtained in the presence of one of the more gross renal tumours. Definite information will not be obtained from renal function estimations, but it seems probable that the functional capacity of the kidney in a case such as ours will be less impaired than it would be in a case of advanced tumour, stone, or tuberculosis.

It is of importance to exclude that type of essential hæmaturia arising in subepithelial pelvic hæmorrhage, as this not uncommon condition appears to respond to non-operative treatment, and any operation therefore must be considered unjustifiably mutilating unless other less drastic lines of treatment have been explored without success. Such measures as that recommended by Rytina (1920)—namely, the intrapelvic injection of 4 to 10 c.c. of a silver nitrate solution 1 to 5 per cent in strength—would appear to have some value

as a therapeutic test. This author reports the cure of three cases, one of which had been aggravated rather than improved by a previous nephrotomy.

The clinical course of the illness acquires more definite significance after such extensive investigation is complete. In the absence of features indicating another lesion, it might be justifiable to suspect the presence of an angioma of the renal pelvis when hæmaturia is met with, particularly in a fairly young person, dramatic in onset, and so severe as imperatively to demand surgical intervention. The acuity of the course which is generally followed by the disease is illustrated in *Table I.*

TREATMENT.

The angioma is a simple tumour, generally fairly small in size, and sacrifice of an entire kidney may appear to be a surgical extravagance. Superficial angiomata of the parenchyma probably rarely require surgical treatment. Tumours or varices of the papillæ may be cured by papillectomy or nephrotomy. If nephrotomy revealed in an accessible position a small angioma, it would be attractive to attempt its removal by some form of electrocoagulation. But in a case such as that reported above, in which hæmorrhage so severe as to endanger life occurred in eight days, a possibly unsuccessful operation is not lightly to be undertaken, and conservation would be difficult and undoubtedly hazardous in such a case where a fairly extensive angioma was present in a somewhat inaccessible situation. In these circumstances, and in the presence of another kidney free from disease, nephrectomy would seem to be the swiftest and surest road to a satisfactory cure.

SUMMARY.

1. A case is reported in which dangerous hæmaturia arose from a cavernous hæmangioma of the renal pelvis.

2. Seventeen examples of hæmangioma of the kidney have been collected from the literature.

3. The material has been classified and an attempt has been made to correlate symptoms with the situation and pathological characters of the lesions.

4. The treatment of the various lesions is briefly considered.

I am much indebted to Mr. Roy Young, Visiting Surgeon to the Western Infirmary, Glasgow, for the use of his clinical records, the pyelogram, and the drawing by Mr. R. M. Buchanan, M.B., of the museum specimen. The excellent photomicrographs are by Mr. John Kirkpatrick, of the Department of Pathology, Glasgow University.

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SARCOMA AND TRAUMA.

By R. J. WILLAN, M.V.O.,
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It has been established in a court of law that for purpose of compensation sarcoma can be held to be a sequel to trauma. The following case illustrating this possible relationship is of considerable interest. The accident was officially reported to the patient's employers, and he continued to do

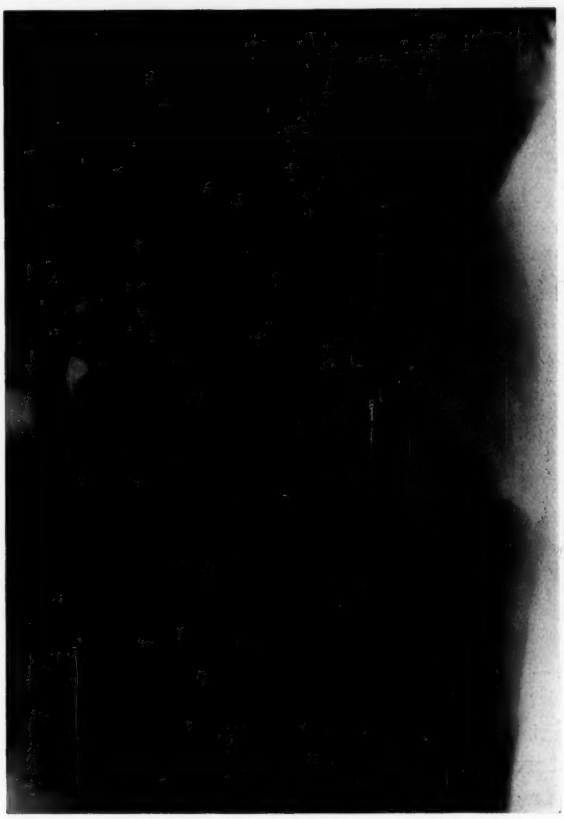

Fig. 199.—Skiagram of hip-joint taken three months after the accident.

arduous work for ten days after the accident, when his employment ceased. I saw him first exactly three months after the accident, when he complained of acute but vague pains. At that time the physical signs were normal, as were radiograms of the hip-joint and femur.

A spontaneous fracture of the neck of the right femur appeared within

eight months after the accident, the exact date of the fracture being uncertain; at the same time deposits of growth were found in the clavicle and humerus. The patient died from cachexia one year and eleven months after the accident, and a post-mortem examination confirmed the ante-mortem diagnosis of sarcoma. The possibilities are: (1) Primary growth in the femur, with secondary deposits in the clavicle and humerus; (2) Primary growth in the clavicle or humerus and secondary deposits in the femur, for no radiogram of the shoulder area was taken until eight months after the accident; (3) That the accident was a coincidence and in no way connected with the sarcoma.

FIG. 200.—Skiagram of hip-joint taken eight months after the accident.

Assuming that the accident really was responsible for the onset of sarcoma, it is interesting to compare the two radiograms—*Fig.* 199, taken three months after the accident, and *Fig.* 200, taken eight months after. It is also interesting to speculate whether the sarcoma arose from the traumatized tissue, and if so, when the sarcomatous change took place.

CASE REPORT.

HISTORY.—On July 25, 1928, Thomas B., age 51, labourer, was working in a railway truck and sustained an accident. The 'Accident Report', which he filled in for compensation purposes, stated that he had sustained a "bruise

to the thigh" caused by "slipping and falling to the ground when climbing out of the truck". The accident was not reported officially until fourteen days after its occurrence, but liability for compensation was accepted and was paid. Evidence was subsequently obtained as to the presence of the bruise over the right femoral trochanter, also that the bruise lasted for about six weeks.

The man continued to work as a labourer until Aug. 4—that is, ten days after the accident—when he was paid off owing to slackness of trade. Prior to the accident his panel doctor, Dr. MacElroy, of Blackhill, states that he was quite well in every way.

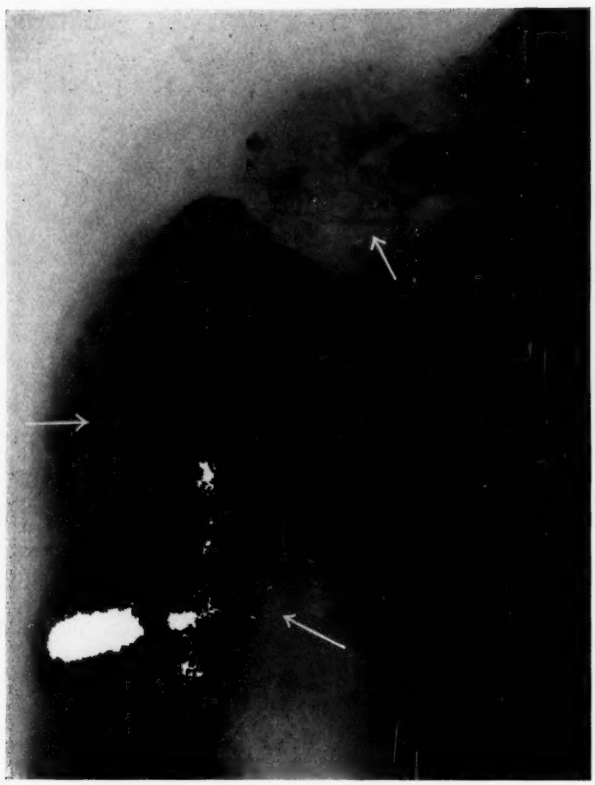

FIG. 201.—Skiagram showing the growths in the outer end of the clavicle and the upper end of the shaft of the right humerus.

FIRST EXAMINATION.—The patient continued to have unaccountable pains which simulated sciatica and lumbago, so in October, 1928, Dr. MacElroy sent him to see me at the Royal Victoria Infirmary, Newcastle, as an out-patient. He then had no abnormal physical signs in the right hip and lumbar vertebral joint areas—that is, there was no muscle wasting or rigidity, nor was there any limitation of movement in the right hip-joint or lumbar vertebral joints. His hip-joint was X-rayed on Oct. 25 (*Fig.* 199), but nothing abnormal could be made out. A radiogram of the right side of the pelvis also showed normal shadows. No complaint whatever was made of the shoulder-joint, either to

Dr. MacElroy or to myself; it was therefore not examined by me on this occasion. The pains gradually became worse, the hip-joint area swelled up, walking became increasingly more difficult, and by January, 1929, the patient was bedfast.

SECOND EXAMINATION.—I next saw him in March, when there was a pathological fracture of the neck of the right femur. He then complained of pain in the shoulder for the first time, and it was noticed that he had a swelling in the region of his right shoulder and at the outer end of the right clavicle. X rays (*Figs.* 200, 201) showed a growth in the neck of the femur, the outer end of the clavicle, and the upper end of the shaft of the right humerus.

ON ADMISSION.—In October the patient was admitted under my care at the Royal Victoria Infirmary, Newcastle, as an in-patient; radiograms showed that the growths had increased in size. His general condition became

FIG. 202.—Microphotograph of growth in right femur. (× 80.)

progressively worse, both right hip-joint and right shoulder area swellings gradually increased in size, and he died from cachexia on June 10, 1930—nearly two years after the accident.

AUTOPSY.—A post-mortem examination made by Dr. W. E. Hume and myself revealed a growth of large size originating in the neck of the right femur with a fracture; the growth was like brain in appearance, and similar growth distended the outer half of the right clavicle and upper end of the right humerus; the growth had the appearance of a sarcoma. There was no evidence of neoplasm in the thoracic or abdominal viscera.

PATHOLOGICAL REPORT.—A piece of the growth was submitted to Professor Stuart MacDonald for examination, and he reports: "This tumour is certainly neoplastic, and is of the nature of a spindle-cell sarcoma. This portion of tissue is well preserved, is not necrotic, and shows no evidence of bone formation." *Fig.* 202 is a microphotograph of the growth.

SUMMARY.

The case is a spindle-celled sarcoma of the femur associated with an undoubted injury to the same area. X rays showed a normal bone three months after the accident; within the next five months there was a spontaneous fracture from the growth. Similar growths were found in two other bones. Death took place one year and eleven months after the accident. Sarcoma was confirmed by a post-mortem examination. It is true that the connection between the trauma and sarcoma rests only on circumstantial evidence, but it appears to me unlikely that a more certain chain of evidence can be obtained than in this case.

I am indebted to the Honorary Physician to the Electrical Department of the Royal Victoria Infirmary, Newcastle, for *Fig.* 199, to Dr. W. D. Arnison for *Figs.* 200 and 201, and to Professor Stuart MacDonald for the pathological report and the microphotograph.

FATAL CARDIAC FAILURE OCCURRING IN PERSONS WITH ANGULAR DEFORMITY OF THE SPINE.

By CAREY F. COOMBS,

PHYSICIAN, AND IN CHARGE OF UNIVERSITY CENTRE OF CARDIAC RESEARCH, BRISTOL GENERAL HOSPITAL.

During the past few years I have seen four examples of the condition described in the title of this paper. Brief notes of these follow :—

Case 1.—A married woman, age 38, was admitted under my care at the Bristol General Hospital suffering from dyspnœa of twelve months' duration. For the first three or four months this had been worse, and dropsy had been added to it. There was pronounced cyanosis of the face, and the fingers were clubbed and purplish. The pulse-rate was 130 per minute, the rhythm being regular. The blood-pressure was 100 mm. Hg systolic, 80 diastolic. There was marked kyphosis of the thoracic vertebræ, with compensatory lordosis in the lumbar region, said to date from the age of 2 years. The cardiac impulse was increased in area towards the left, and was diffuse. A cantering rhythm was heard at the apex, and the pulmonic second sound was much accentuated. The œdema was of the cardiac type, being limited to dependent parts, but it was extreme and had to be relieved by the insertion of Southey's tubes into the legs. The urine contained albumin and some blood. The patient was temporarily relieved by treatment, but became strange in her manner and developed bronchitis, dying twelve days after admission.

Autopsy.—Post mortem the principal change was a globular dilatation of both ventricles, without valvular or pericardial disease. The walls of the two ventricles were approximately of the same thickness.

Case 2.—A youth of 19 was admitted under me at the General Hospital for abdominal pain with vomiting and fever. At the age of 7 he was operated on for tuberculosis of the hip, and by the time he was 13 had developed angular curvature of the cervico-dorsal spine, apparently due to vertebral caries. He had been under treatment for this since, and was recently considered to have tuberculosis in both lungs. While he was in the hospital he passed through an illness which was labelled bronchopneumonia. The sputum contained pneumococci but no tubercle bacilli. He was cyanosed on admission, but while he was convalescent from this acute illness he became more so, and developed a general dropsy. The cardiac dullness became widened, a cantering rhythm was noted at the apex, and marked accentuation of the second sound at the pulmonic base. Below this, over a restricted area in the centre of the precordium, a systolic murmur was heard. The pulse-rate varied from 110 to 140, but the rhythm was normal and there was no alternation. The blood-pressure reading was 130/110. While the patient was in this state his parents insisted on taking him home. He died shortly after. There was no autopsy.

Case 3.—A man of 23, admitted to the General Hospital under my colleague, Professor E. W. Hey Groves, for spinal tuberculosis, developed symptoms of circulatory failure. The onset of the spinal lesion dated back to the age of 2, but he had been able to walk till six months before admission. There was a marked kyphosis, with its apex in the seventh dorsal vertebra, and a spastic paraplegia of the lower limbs. He was deeply cyanosed, and had been short of breath for about four months. The pulse-rate was 110 and its rhythm regular. The blood-pressure was 160/110. The back and legs had recently become œdematous. The cardiac dullness was

increased to the right, and a triple rhythm was heard at the apex. The urine was albuminous. The patient became rapidly worse and died.

AUTOPSY.—Post mortem the thoracic aorta was found to follow the dorsal spine into an angle, at the apex of which it was sharply kinked and therefore narrowed. The lungs were fibrous, and adherent to the pulmonary artery at its base. Both ventricles showed considerable dilatation, and the wall of the right ventricle was relatively thickened.

Case 4.—A man of 29 was seen by me in consultation with Dr. R. B. Britton on account of rapidly ingravescent cardiac failure. There was a kypho-scoliosis of the dorsal spine which had been first noted at the age of 3. It was said that his brother had been similarly deformed, and that in his case also this had ended in cardiac failure. The patient was dyspnœic and cyanosed, and had been so for two months. Recently he had become dropsical, and was now œdematous to the waist. The pulse-rate was 120 and the rhythm regular. The blood-pressure was 120/100. The heart-sounds were weak, but the aortic second sound was much accentuated. A 'bruit de galop' was noted. There were râles at the bases, and a trace of albumin in the urine. He died a few days later. Post-mortem examination was not feasible.

COMMENT.

All these patients displayed a gross deformity of the dorsal spine. In three there was an angular kyphosis of tuberculous origin. In the other the angulation was lateral as well as antero-posterior, and was said to have occurred in another member of the family, in association with symptoms of cardiac failure like those which my patient experienced. All these four subjects had been deformed for many years; three of them, indeed, since early childhood; but not until a few months before death—twelve months in one case, less than six months in the others—were there any cardiac symptoms. In all, the first complaint was of dyspnœa, and this increased rapidly until it reached an extreme degree. By the time that I saw them, all four were very cyanosed, and in one case—that of the woman—the fingers were clubbed and purple. In all of them there was an extreme and increasing dropsy up to the waist-line.

The pulse was quick but regular in every instance; the blood-pressure was low and the pulse-pressure gap very narrow in three of the four patients. Unfortunately no electrocardiograms were taken, as all four patients were extremely ill when first seen. Alternation of the pulse was not detected in any of them.

The physical signs were so distorted by the deformity of the chest that not much could be definitely established. It is, however, worthy of note that the impulse was always diffuse and the basic second sound relatively loud, while in all a 'bruit de galop' was heard. Physical signs of bronchitis, amounting in one instance to a bronchopneumonia, were also observed.

Post-mortem examinations were made in two cases (*Cases* 1 and 3). These, while incomplete, did at least confirm and explain the evidences of cardiac embarrassment. In *Case* 1, that of the woman of 38, a globular enlargement of the heart was noted, in which both ventricles shared, the wall of the right chamber being as thick as that of the left. Neither pericardium nor valves showed any gross change. This is true also of the heart in *Case* 3. Here we noted a remarkably acute angulation of the aortic arch, which had

been thus penalized for clinging too faithfully to the deformed spine. In this case also there was some fibrosis round the root of the pulmonary artery, as well as a manifest reduction in the capacity of the lungs.

The references to this form of cardiac failure are almost limited to Continental journals. There are but few papers in English dealing with the subject. I shall not attempt a review of what has been written, but one or two points are of general interest. First, the aortic kink seen in one of my cases was described by Morgagni. Second, it is stated by some orthopædic surgeons that enlargement of the heart is noted in a majority of kyphotic patients. Finally, three influences have been blamed for the cardiac failure: aortic kinking, inadequate air-space in the lungs, and restriction of the diaphragmatic excursion. Whatever the explanation, it is clear that there is a real danger of untimely death from cardiac failure in the victims of angular deformity of the spine, and it is by way of affording to the orthopædic surgeon an added reason for attempting to prevent that deformity that this note has been written.

SHORT NOTES OF RARE OR OBSCURE CASES

PIGMENTATION FROM BISMUTH ABSORPTION AFTER THE USE OF B.I.P.P.

By Sir W. I. de COURCY WHEELER, Dublin.

Bismuth in the treatment of syphilis was abandoned for a time some years ago owing to the severe toxic effects of the salts then used. Toxicity was found to be largely influenced by the rate at which the metal entered the circulation.

Fig. 203.—Chronic osteomyelitis of the femur before the operation.

The most notable effects of poisoning were stomatitis, nephritis, and enteritis. The commonest sign of intolerance is a slaty-blue line commencing on the gums

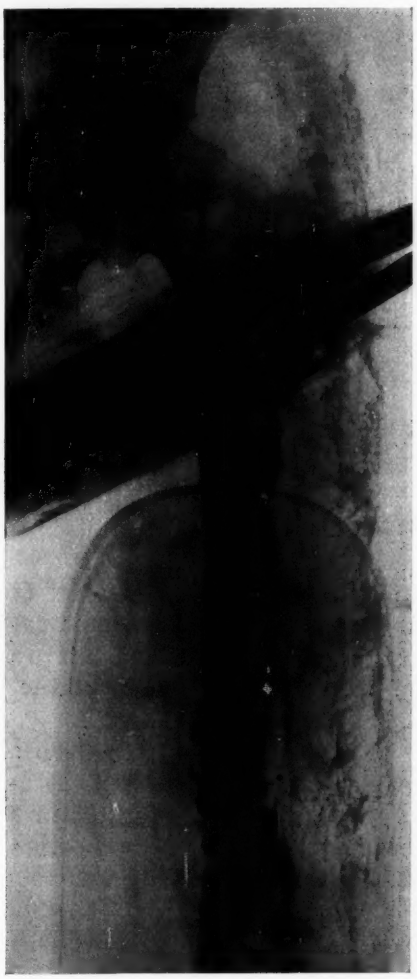

Fig. 204.—Chronic osteomyelitis of the femur after radical operation, showing B.I.P.P. *in situ*. (Note pathological fracture.)

before or behind the incisor teeth. This blue deposit extends to the entire gum margins or inner side of the cheeks from continuous absorption. In severe cases a condition of cancrum oris may be found. Before the War pigmentation of the gums was usually associated with lead poisoning or purpura, or the use of charcoal tooth-powders; during the War it was seen occasionally following the application of bismuth paste to open wounds.

The figures illustrate the case of a boy, age 15, who had suffered from chronic septic osteomyelitis and multiple sinuses of the femur for many years (*Fig.* 203). The bone was exposed through an incision from the trochanter to the knee and a radical operation performed with the aid of a motor saw. About a teaspoonful of B.I.P.P. was smeared over the raw surfaces (*Fig.* 204). About a week after operation the patient looked toxic and albumin had appeared in the urine. On examination of the mouth, the under surface of the tongue was found deeply pigmented. The lower alveolar margin both

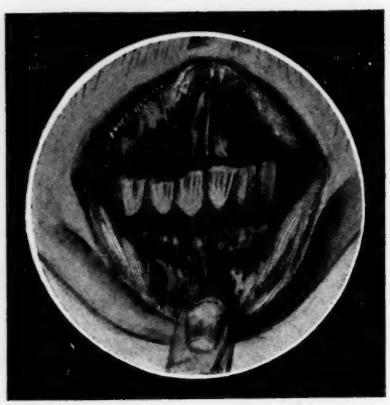

FIG. 205.—Deep pigmentation (suggesting imminent sloughing) of the gums, under surface of the tongue and lower lip, and the mucous membrane of the cheeks, after the application of B.I.P.P. in a case of osteomyelitis.

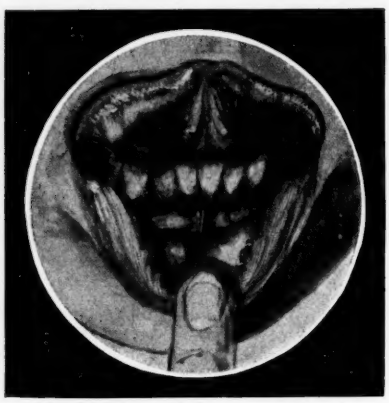

FIG. 206.—Same case six weeks later after treatment by nineteen intravenous injections of ametox given on alternate days. Suction drainage was applied to the reopened wound.

front and back was in the same condition. The deep surface of the lower lip was also deeply stained, as was the inner side of each cheek (*Fig.* 205). The appearance was such as to suggest the possibility of sloughing. The characteristic translucency of the blue stains could be well seen by means of a Cameron light.

The patient was treated on alternate days by intravenous injections of ametox, a preparation used as an antidote to poisoning from N.A.B., but said to be equally effective in poisoning from other heavy metals. The wound in the thigh was laid completely open, and a large cigarette drain with a catheter in the middle was connected with an electrical aspirator (Lovac) under the bed. A large amount of bismuth-stained septic material was removed in this way. In about a fortnight the pigmentation was less marked and the patient's condition improved (*Fig.* 206). The operation was performed on Jan. 30, 1930. Six months later, after treatment in an open-air hospital, the pigmentation had almost disappeared.

A CASE OF CONGENITAL STENOSIS OF THE DUODENUM.

By LENNOX GORDON,
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While stenosis of the duodenum of congenital origin is a well-recognized abnormality, its occurrence is rare. The following case is noted as it brings out some points of interest, the chief being perhaps the age to which the child lived—2½ years—in spite of a very marked degree of stenosis. The difficulty in diagnosis is also of interest.

The patient was a 'coloured' boy, age 2 years and 6 months, who was admitted to hospital with the query diagnosis of 'nephritis', this diagnosis evidently being suggested by the fact that the child had œdema of the face, hands, and legs.

History.—The mother was a coloured woman of poor mentality, and it was not until after the child's death and careful questioning that she gave the following important history. She stated that the patient had suffered from frequent attacks of vomiting, the abdomen became distended, but this distension subsided as the vomiting ceased. These attacks occurred about once a month, and during the quiet intervals the child, although always thin, seemed well and contented. The mother had consulted a doctor about the patient because of the swelling of the extremities and face, and the child was not taking its food well. There was no distension of the stomach at the time.

Course.—The patient was admitted to the pædiatric department of the hospital and was under medical observation. The œdema disappeared within a few days, and was thought to have been due to some form of dietary deficiency; there was no evidence of nephritis. The child was for three weeks under careful medical observation, and nothing definite could be made out beyond that he appeared ill nourished. There was no vomiting, and no distension of the abdomen was noted. He passed some worms, for which a vermifuge was given.

After being in hospital three weeks the child was seized late one night with sudden acute symptoms. He started vomiting, the abdomen became greatly distended, the temperature rose, and the pulse-rate increased. By next morning he was extremely ill, the abdomen was greatly distended, and the vomiting was frequent and had now become bile-stained. Everything pointed to an acute obstruction and surgical aid was asked for. The child was now so extremely ill that the chance of relieving any obstruction by operation appeared remote. As a forlorn hope a small laparotomy opening was made under local anæsthesia and light ether, the stomach having first been washed out and a large kidney dish of bile-stained stomach contents drawn off. On opening the abdomen a greatly distended stomach and first part of duodenum was found, but before any further investigation or operative procedure could be carried out the child became suddenly worse.

As one wished to get the patient off the operating table alive the abdomen was closed, but he died while being stitched up.

POST-MORTEM EXAMINATION (carried out by Professor Ryrie).—Beyond a stenosis of the duodenum no other pathological lesion was discovered.

The duodenum was constricted in its second part in the region of the ampulla of Vater. The length of the constricted portion was about three-quarters of an inch, and the stricture just admitted a probe 3 mm. in diameter. Both the stomach and duodenum proximal to the stricture were markedly dilated, the distended part of the duodenum being as large as the stomach; the muscular walls were hypertrophied and the pyloric opening was freely patent. The opening of the common bile-duct was involved in the stricture, being more to the distal side, but there was no apparent obstruction of the bile-duct, as bile passed freely into the proximal

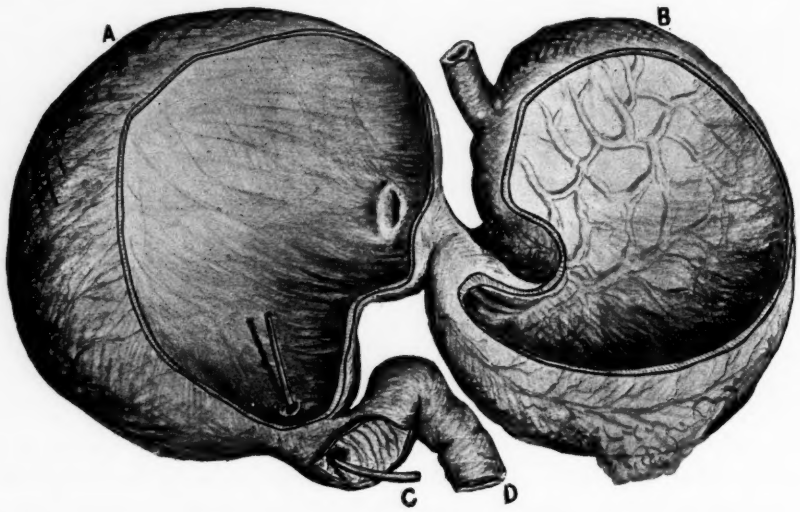

FIG. 207.—Appearance found on autopsy. A, Dilated duodenum; B, Stomach; C, Probe through stenosis; D, Duodenum. (×⅔.)

dilated part of the duodenum. This would explain why the vomited material was bile-stained. The post-mortem appearance is shown in the accompanying sketch (*Fig.* 207).

Comment.—The special points of interest in this case appear to be: (1) The age to which the child lived, namely 2½ years; (2) The fact that while under careful observation for several weeks there was no evidence of distension or obstruction.

These cases of duodenal obstruction usually die within the first few months of life. The longest case hitherto recorded is that of a girl who lived 2½ years, and then died as the result of an acute obstruction from an impacted portion of food in the stenosed opening. The present case is therefore also interesting as regards the child's longevity.

The pathology has been discussed by various writers. The main feature

is that (apart from obstruction due to bands and adhesions) the stricture occurs either in the region of the papilla of Vater or at the duodenojejunal junction, the site being determined by Bland-Sutton's generalization that these occlusions occur at the site of embryological events. At the region of the papilla of Vater the liver and pancreas bud off, and this region is the meeting-place of the fore- and mid-gut.

The point of practical interest is the diagnosis. If the symptoms are recognized early, operation may save the patient's life. The chief symptom is vomiting; this starts usually soon after birth; it is in the large majority of cases bile-stained, and is forcible in character. The child is constipated, and wasting is evident. The symptoms closely resemble those of congenital pyloric stenosis. The points which may help to distinguish the two are that in duodenal stenosis the vomiting is said to begin at birth, it is usually bile-stained, and, further, no tumour is to be felt. An X-ray picture will of course be of great value, showing that food passes the pylorus and that it is the duodenum which is distended.

The treatment is surgical. The child's life may be saved by a short-circuiting operation, or, if the obstruction is due to bands, by dividing these.

A CASE OF CONGENITAL ATRESIA OF THE SMALL INTESTINE.

By CYRIL POLSON,

LECTURER IN PATHOLOGY, UNIVERSITY OF LEEDS.

The present case is an example of atresia of the ileum, and resembles that described by Pasley[1] in 1929. It belongs to the third group of Forssner's[2] classification—namely, the type in which there is a complete break in the continuity of the small intestine, with the closed ends unconnected except by mesentery. Morley (1921) reviewed the literature concerning congenital occlusion of the ileum, and reported two examples.[3]

The patient was a male, age 5 days, admitted to hospital on March 21, 1930, with a history of vomiting since birth. The vomit was brown and fæculent. One motion of small size was passed on March 19. The child lost weight, and was described as "ill, wasted, and dehydrated". On March 21 he vomited fæcal matter twice during the night. No result followed the administration of two enemata, but a small amount of mucus was passed per rectum. Intestinal obstruction due to congenital malformation was diagnosed, but the child was too ill to submit to operation, and died on March 23.

Autopsy.—The body was that of a wasted male child. When the abdomen was opened the coils of small intestine were prominent and dilated, suggesting obstruction. The stomach and duodenum were not dilated, but the small intestine became increasingly distended as it was traced distally, ending in a bulbous extremity about two inches in diameter at a point nine inches from the ileocæcal valve. The continuation of the ileum began as a

similar but much smaller blind end. Between them there was a wedge-shaped gap in the mesentery, the free border of which did not appear to contain any intestinal tissue. Distally, the ileum had but the diameter of a pencil, and passed upwards to join the cæcum in a normal manner. The drawing of the specimen (*Fig.* 208) illustrates these points clearly. Two enlarged lymphatic glands were present in the mesentery within the intestinal gap. The cæcum was displaced upwards and lay beneath the right lobe of the liver. The

FIG. 208.—Condition found at autopsy. A, Blind end of proximal ileum; B, Blind end of distal ileum; C, Appendix; D, Cæcum; E, Colon; F, Lymph gland; G, Gap in ileum.

appendix, cæcum, colon, and rectum were all narrow and atrophic. The colon, although less than a quarter of an inch in diameter, was perfectly formed. The anus was patent and admitted forceps to the rectum. Histological examination failed to demonstrate any intestinal tissue in the mesentery between the blind ends of the small intestine.

I wish to thank Professor C. W. Vining for permission to use his notes of this case, and Miss Collinson for the drawing.

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UTERUS MASCULINUS:

COMPLETE TUBULAR HERMAPHRODITISM, WITH TERATOMATOUS ENLARGEMENT OF AN UNDESCENDED TESTICLE.

By R. H. METCALFE,

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A YOUNG man (H. P. M.), 31 years of age, came to the out-patient department at the General Hospital, Birmingham, on April 2, 1930, complaining of abdominal pain and the presence of a large abdominal tumour arising out of the right iliac fossa.

EXAMINATION AND HISTORY.—The individual possessed all the external features of a well-developed man: he had a normal beard and growth of pubic hair; he had a bass voice; his penis was normal and well developed; there was no abnormal enlargement of the breasts. The only abnormal condition noted, apart from the presence of the abdominal tumour, was the fact that the testicles were undescended.

There had never been any doubt as to his sex—in fact, the individual had been married for seven years, and stated that he had had normal intercourse with his wife, with what he considered was a normal emission; the marriage, however, was childless, and the husband had gone so far as to have his wife examined by a gynæcologist.

In view of what was subsequently found, it is of interest to note that there was no history of menstruation or of monthly discomfort, neither was there any history of the passage of blood either per urethram or per rectum. There was an indirect hernia present on the right side, but this was easily reducible, and had never given rise to any trouble.

The patient was admitted to the General Hospital on April 7 under Mr. Seymour Barling, who performed a laparotomy on April 10.

OPERATION.—The abdomen was opened by a mid-line incision below the umbilicus: a large, smooth, bossy tumour presented itself and appeared to be free from adhesions, except for a few slight ones in the pelvis on the right side; these were freed, and the tumour was easily delivered outside the abdomen.

The tumour was found to be attached by a definite mesentery to the posterior surface of a structure which had the appearance of a broad ligament. Just above this was a tube with a fimbriated end, and these, on being traced towards the middle line, led to a rudimentary uterus, to the left side of which were attached a further Fallopian tube and broad ligament, normal in both size and position. An apparently normal 'ovary' was also found lying in its normal position on the left side. A complete excision of the upper part of the uterus and of both tubes and 'ovaries' was performed.

When the body of the uterus was divided, a canal about 1 cm. in diameter was found; a probe was passed down this canal for a distance of 15 cm. With a finger in the rectum, the tip of the probe was palpated

through the anterior wall of the rectum, lying in the mid-line just above a perfectly normal prostate. The probe itself could not be felt, and no communication between the uterine canal and the rectum was found. The raw areas in the pelvic floor were then peritonized and the abdomen was closed.

PATHOLOGICAL REPORT.—The excised specimen was examined in detail, and the general arrangement is well shown in the accompanying sketch (*Fig.* 209). The two tubular structures, seen lying in the angles between the uterus and the Fallopian tubes, had all the normal macroscopic appearances of vasa deferentia.

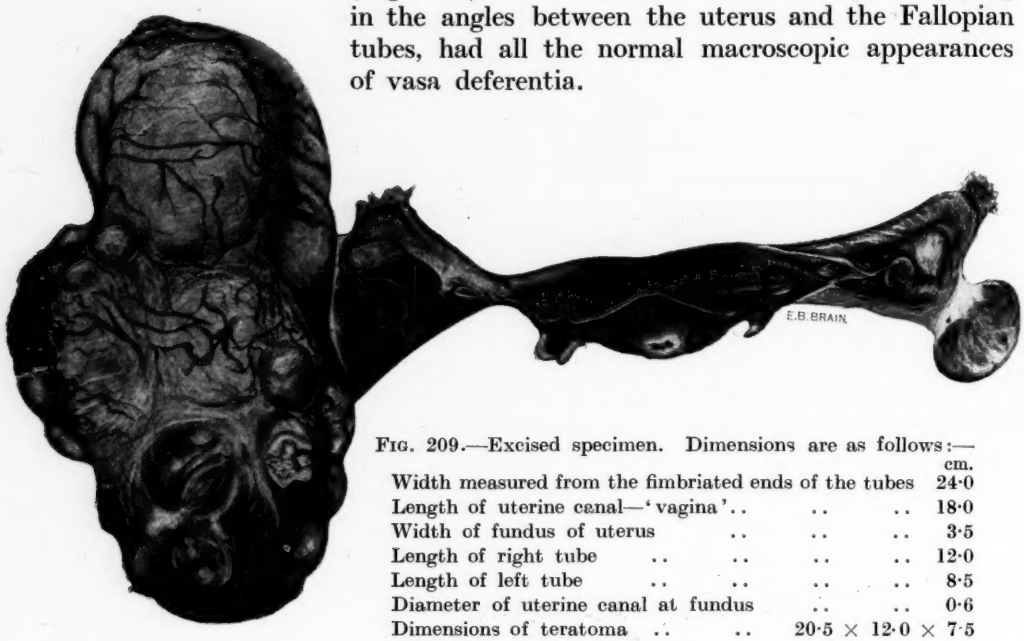

FIG. 209.—Excised specimen. Dimensions are as follows:—

	cm.
Width measured from the fimbriated ends of the tubes	24·0
Length of uterine canal—'vagina'	18·0
Width of fundus of uterus	3·5
Length of right tube	12·0
Length of left tube	8·5
Diameter of uterine canal at fundus	0·6
Dimensions of teratoma	20·5 × 12·0 × 7·5
Dimensions of normal 'ovary' ..	3·0 × 2·4 × 1·6

As will be seen in the sketch, the whole arrangement of the uterus and tubes is exactly similar to that found in a normal female. The various parts of the specimen were cut and examined under a microscope. The following report was made:—

1. The tumour is composed of spheroidal cells and has a scirrhous form. The characters of the cells are those of an embryonal carcinoma of the testis.
2. The 'ovary' (?) is a testis, in which the interstitial cells are unduly prominent and the testicular tubules rather atrophic.
3. The tube near the angle of the uterus is a normal vas.
4. The lining of the uterine canal is tall columnar epithelium.

Cases of uterus masculinus have been recorded from time to time, but after a search of the literature, going back as far as 1855, no case has been found in which the reported female arrangement is as perfect as in the specimen described.

Langer[1] in 1855 reported a case in which the uterus and vagina measured 12·5 cm. in length—the 'ovaries', as in the present case, were mere testes. In 1888 the same author reported a second case, but the parts were smaller and

measured only 6 cm. in length. This case is of interest as normal vesiculæ seminales were found to be present; in practically all other cases these outgrowths from the vas are not found.

Willett[2] reported a case in which the man was married, and his wife had children; but here, as in the last case, the parts were very rudimentary and measured only 4 cm. in length. Nearly all the other cases recorded have been sterile.

Primrose[3] in 1898 reported a case very similar to the present one: here the patient complained of an abdominal tumour, which on laparotomy was found to be a teratoma of the testis lying attached to a rudimentary Fallopian tube. The uterus and vagina in Primrose's case measured 12 cm., as compared with 18 cm. in the present instance.

Several other cases of a similar nature are recorded, one being that of a French soldier in 1918,[4] who was married and whose wife had borne children, and another being a child of 2 years of age, reported by Rutherford[5] in 1929.

Cases of 'true hermaphroditism' occurring in man are found reported in the literature. In the majority of these, microscopical examination was not made of the glandular organs, and such cases must therefore be excluded: a few apparently conclusive cases remain.

It must be stressed that by 'true hermaphroditism' is meant a condition in which there exist in the same individual an ovary and a testis. This condition is what is known by the French authors as 'glandular hermaphroditism', as distinct from 'tubular hermaphroditism', the latter term being reserved to describe cases similar to the present one, and to those already quoted in this paper—that is to say, cases in which both the Müllerian and the Wolffian ducts persist in the same individual.

All degrees of 'tubular hermaphroditism' can occur, ranging from the rudimentary uterus masculinus, as normally found, to the complete persistence of the Müllerian ducts, as in the present case. This case is recorded as a perfect example of 'tubular hermaphroditism'.

I am indebted to Mr. Seymour Barling, Senior Surgeon to the General Hospital, Birmingham, for permission to publish details of this case.

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[4] COUVELAIRE and DUCLAUX, *Ann. de Gynécol. et d'Obst.*, 1918–19.

[5] RUTHERFORD, "Case of Undescended Testicle with Uterus and Fallopian Tube", *Jour. of Anat.*, 1929, Oct., lxiv.

A RARE NECK CYST.

By IAN FRASER,

ASSISTANT SURGEON TO BELFAST HOSPITAL FOR SICK CHILDREN.

THE patient, Mrs. B., a widow aged 65, was referred to me for removal of a tumour in the neck.

HISTORY.—The swelling had appeared suddenly and painlessly five years previously and had remained constant ever since, and now she wished its removal for cosmetic reasons only.

ON EXAMINATION.—A smooth oval tumour, exactly the size of the average hen's egg, was felt. It was situated in the upper part of the posterior triangle of the neck. It lay deep to the deep fascia, and was freely movable in all directions with muscles either slack or tense. There were no other swellings or abnormalities present in the neck. The tumour was not affected by deglutition or posture, nor did it vary in size. It was absolutely painless, not tender, and the overlying skin was normal. Translucency could not be tested on account of its depth. On palpation the swelling was single, smooth, not lobulated, and if cystic was very tense, but it felt solid lying as it did partly under the trapezius. Sebaceous cyst, dermoid, branchial cyst, branchiogenetic carcinoma, lipoma, and cystic hygroma were considered and excluded, and eventually it was agreed that the swelling must be a gland—perhaps tuberculous and perhaps undergoing caseation—though no focus in scalp, ear, or other drainage area could be found.

OPERATION (January, 1930).—An oblique incision three inches long was made over the swelling through skin, superficial fascia, and deep fascia. The tumour, which proved to be a tense cyst, shelled out with ease. It was thin-walled, and filled with white particles floating in a clear medium; the white bodies rapidly fell to the lower pole of the cyst. No diagnosis was made.

Fluid aspirated from the cyst showed it to be filled with active scolices, making the diagnosis of hydatid cyst definite. Further physical examination of the patient failed to reveal any suspicious masses in the liver or chest. An eosinophil count of 12 per cent confirmed the active nature of the parasite.

On subsequently questioning the patient I asked her had she ever been 'abroad'; after due consideration she said 'yes'—eight years ago she had been to Scotland for the day! A real item of interest in the case was the patient's extreme fondness for dogs. Her last pet (which with tears she explained had paid the supreme sacrifice at the hands of a reckless motorist) was now stuffed and retained as a pathological specimen in a glass case.

Comment.—Owing to the rarity of the condition in this country the case seems worth publishing. The points which it exemplifies are: (1) Hydatid cysts do occur sporadically in this country; (2) There is a close connection with the dog; (3) A single cyst can appear in the territory of the systemic

circulation without any signs in the portal area ; (4) The cyst contents can remain highly active after five years.

I wish to record my thanks to Dr. Blake, who referred the case to me, and to Professor Drennan, Queen's University Pathological Department, who made an accurate diagnosis possible.

DERMOID CYST SIMULATING GASTRIC ULCER.

By R. J. McNEILL LOVE,
SURGEON TO ST. ANDREW'S HOSPITAL, POPLAR.

Dermoid cysts have been found in almost every part of the body, and when occurring in unusual sites are apt to lead to erroneous diagnosis.

Fig. 210.—Skiagram from a case of dermoid cyst simulating a gastric ulcer. Note the opacity near the upper part of the greater curvature.

The following case is of interest in that the cyst in question simulated a gastric ulcer.

Mrs. E. C., age 53, was admitted to St. Andrew's Hospital, Poplar, after a brisk hæmatemesis, which was alleged to have exceeded a pint.

History.—The patient stated that for the past five years she had suffered from pain an hour to an hour and a half after food, but periodicity of symptoms

was indefinite. The pain was epigastric, and was relieved by the occasional vomiting with which it was sometimes accompanied. There was no loss of weight, and the general health was good. Two years previously she had been in hospital for a severe attack of pain accompanied with hæmatemesis.

On Examination.—She was well nourished, and no physical signs could be elicited. Blood examination revealed a slight degree of secondary anæmia. A bismuth meal showed a normal stomach, but near the upper part of the greater curvature a curious opacity was noticed (*Fig.* 210). This was considered to be a calcified hydatid cyst, and although the patient had never been abroad, her residence in Poplar supported this diagnosis, as hydatid

Fig. 211.—Dermoid cyst removed from the gastrosplenic omentum. The figure on the right shows the contents of the cyst. ($\times \frac{3}{4}$.)

cysts occasionally occur in this locality owing to the proximity of the docks. Calcification of the cyst was considered sufficient explanation for the absence of eosinophilia.

Operation.—As symptoms persisted a laparotomy was performed, and a hard rounded swelling about the size of a cricket-ball was discovered in the gastrosplenic omentum. This was easily shelled out, and proved to be a dermoid cyst, containing sebaceous material, rudimentary teeth, and hair (*Fig.* 211). All other viscera were healthy, and the hæmatemesis was presumably due to pressure on the vasa brevia veins.

Recovery was uneventful, and symptoms disappeared.

REVIEWS AND NOTICES OF BOOKS.

The Edwin Smith Surgical Papyrus. Published in Facsimile and Hieroglyphic Transliteration, with Translation and Commentary. By JAMES HENRY BREASTED. Demy 4to. Vol. I. Pp. 596 + xxiv, illustrated; Vol. II. 22 plates. 1930. Chicago: The University of Chicago Press. London: Cambridge University Press. 90s.

THESE sumptuous volumes should appeal to every surgeon, for the Edwin Smith Papyrus is the earliest known treatise on surgery. It is indeed incomplete at the beginning and at the end, but it gives details of forty-eight cases of injury to the head and neck, and is either the lecture notes of the surgeon who dictated it to the scribe, or the notes of his lectures taken by a pupil. At any rate, it seems to reproduce the very words of the author. The papyrus here copied was probably written in the sixteenth century B.C., and is itself a copy of a roll which may have been written a thousand years earlier, for many of the terms employed had already become obsolete, and the editor found it necessary to interpret them by a series of glosses. In like manner, an editor of to-day, copying a twelfth or thirteenth century English manuscript on anatomy or surgery, finds it necessary to explain many of the words used.

The original writer, who may have been contemporary with Imhotep, the priest-architect-physician when the Great Pyramid was being built, shows himself to have been a skilled surgeon who had seen war service. He had a scientific mind, was practical, and had few if any illusions as to the value of charms and amulets, although a later hand has attached to the copy of the roll a treatise on magic in the approved later style of Egyptian medicine.

The treatise shows that the writer followed a settled plan. He first gave a name to the injury; then made an examination, which it may be noted was always digital, and not by means of a probe or other instrument; offered a diagnosis; and afterward stated that the man could be cured, that an attempt could be made to cure him, or that nothing could be done. The treatment was either exclusively mechanical or surgical, as when a dislocated jaw was reduced in the same manner as it is to-day; a combination of purely surgical treatment with the use of external applications, as when splints were used made of wood and linen or of linen alone impregnated with glue and plaster; or by the employment of external applications only. It is interesting to observe that 'raw meat' was often applied as a dressing for wounds after they had been sutured. The use seemingly has never died out, for as a folk-remedy it was commonly used for a 'black eye', and in modern scientific surgery a piece of living muscle is used to arrest capillary hæmorrhage. It is recommended that the wounds should be stitched, closed by adhesive plaster—probably the diachylon or lead plaster still in use—or by bandages "obtained from the embalmers".

The roll shows some astounding physiological facts, unless we are reading our own knowledge into the words of this very ancient surgeon. After an injury to the head he directs that the pulse should be counted to know the condition of the heart, though he gives no indication that he recognized the circulation of the blood. He knew that there might be a depressed fracture of the skull without the skin's being broken, and that an injury to the brain was followed by loss of speech and paralysis of the limbs. He knew, too, that a dislocation of the vertebræ might lead to incontinence of urine and an emission of semen. There are indications that

aneurysms had occurred in his practice, for he speaks of soft swellings in the front wall of the chest and of similar swellings occurring in other parts of the limbs, adding wisely that their cure should not be undertaken. They might perhaps have been 'cold abscesses' due to tubercle, but these were familiar to Egyptian surgeons and would have been treated by them. Every case is a fascinating study from the surgical standpoint, but a just criticism should be used in their consideration.

Great praise must be given to the editor, Mr. Breasted, for his Foreword, general explanatory notes, and Introduction, all of which are full of information. The papyrus was bought at Luxor by Mr. Edwin Smith in 1862. Mr. Smith was probably the first American citizen to learn scientifically the little that was then known about the Egyptian language, and after his death the roll was presented by his daughter to the New York Historical Society. In 1922, being originally written in hieratic, it was transliterated into hieroglyphic characters, which is as much as to say that if it had been an early English manuscript it was transcribed into modern text hand. Of this transliteration an English version is given with a commentary in the first volume. The second volume reproduces in facsimile the original hieratic roll and the transliteration. The whole is appropriately dedicated to the memory of William Harvey on the three hundredth anniversary of the publication of *De Motu Sanguinis*, and forms the third and fourth volumes of the University of Chicago Oriental Institute Publications.

The printing has been done at the University Press, Oxford, and the plates have been produced by Emery Walker Ltd. Both firms are to be congratulated on the results.

Applied Anatomy. The Construction of the Human Body considered in Relation to its Functions, Diseases, and Injuries. By GWILYM G. DAVIS, M.D., Late Professor of Orthopedic Surgery and Associate Professor of Applied Anatomy in the University of Pennsylvania. Revised by GEORGE P. MULLER, M.D., Professor of Clinical Surgery in the University of Pennsylvania. Eighth edition revised. Super Royal 8vo. Pp. 638 + xii, with 656 illustrations mostly from original dissections and many in colour by Edwin F. Faber. 1929. London: J. B. Lippincott Co. 42s. net.

A BOOK of this magnitude, which has passed through eight editions since its first appearance in 1910, clearly requires no introduction or commendation. Its aim is not merely to relate anatomical facts, but to show the relations of structure to function and to describe the variations in structure which accompany diseased or injured conditions. It is in fact a text-book of surgery based chiefly on the anatomy of the body. There are obvious advantages and disadvantages in this plan of dealing with anatomy and surgery in the same book.

In the first place the practical essentials of anatomy are given without all the unnecessary minutiæ which overload an ordinary text-book of anatomy; and then each surgical deformity or operation is described just when the anatomical picture of the part is fresh in the eye and mind. As against these advantages, however, there is the great drawback that surgery is considered only as a manipulative art, and, whilst the anatomical story runs consecutively, the surgical story is chopped up into little pieces. For example, in a book of this sort we might fairly look for an up-to-date account of the surgery of the sympathetic nervous system, but we look in vain. The sympathetic is not mentioned in the index, the cervical sympathetic and the description of its removal is found in the section on the neck, but we cannot discover any mention of the rami communicantes or of ramisection.

The present edition has appeared shortly after the death of Dr. Davis, whose great interest in orthopædic surgery probably inspired the original idea of the work, because it is in this branch of surgery more than in any other that surgery and anatomy must go side by side.

The illustrations in number, originality, and excellence are such as to ensure the book a place in every reference library.

Die Chirurgie der Brustorgane. By FERDINAND SAUERBRUCH. Third edition. Vol. I. Die Erkrankungen der Lungen. Under the direction of H. ALEXANDER, H. CHAOUL, and W. FELIX. Part 2. Die chirurgische Behandlung der Lungentuberkulose. Die parasitären Erkrankungen der Lungen. Lungentumoren. Die chirurgische Behandlung des Asthma bronchiale. Syphilis der Lungen. Imperial 8vo. Pp. 1373 + viii, with 189 illustrations. 1930. Berlin: Julius Springer. RM. 98.

THE first part of this monumental work has already been reviewed in this JOURNAL. The second part deals chiefly with the surgical treatment of pulmonary tuberculosis, and forms a valuable monograph on this subject. The distinguished author is assisted by Drs. Alexander, Chaoul, and Felix.

The opening chapters deal with the history of the subject, the usual course of pulmonary tuberculosis, and the changes in the lung and chest which occur when natural recovery takes place. The natural falling in of the chest wall and the shrinking of the lung form the basic ideas upon which surgical treatment is founded.

The subject of artificial pneumothorax is then described and discussed in some detail. The theoretical aspect is shortly dealt with and is well illustrated by X-ray pictures, which chiefly show the outline of the contracted lung on the side of the pneumothorax. The pathological anatomy of the method is very convincingly described by figures of the collapsed lung and eleven microscopical preparations, beautifully reproduced in colour, showing the healing process taking place in such an organ. The technique of the operation by puncture or by incision is given, and the method of dividing adhesions under the guidance of thoracoscopy (Jacobeus). The author, however, considers that this complication in technique makes the liability to exudate or emphysema greater, and therefore condemns it. Among the more important complications after pneumothorax are mentioned and illustrated interstitial emphysema, subdiaphragmatic air collection, air embolism, and pleurisy.

In summarizing the results of this method figures are quoted which show that when there are no adhesions 70 per cent of the patients are cured (periods of three to thirteen years). Patients with localized adhesions give only 33 per cent of recoveries, whilst those with wide adhesions show only 11 per cent. The various operations for diminishing the capacity of the chest wall are described and very clearly illustrated. The most complete of such operations (Bauer-Friedrich), in which the greater part of the ribs from the 2nd to the 10th or 11th are removed, is rightly relegated to small print, and the chief stress is laid upon the paravertebral resection of a long piece of all the ribs from the first to the 11th. This is done in two stages, the upper ribs being left for the second operation. There are a number of good photographs and X rays of patients. After this thoracoplasty other operations —e.g., the insertion of fat grafts or paraffin between the collapsed lung and the chest wall, and avulsion of the phrenic nerve—are well described, but the author evidently does not regard such procedures with much favour. One of the most valuable chapters in the book is that in which the indications for surgical treatment of pulmonary tuberculosis are discussed and the importance of co-operation between surgeons and physicians is stressed. There are short chapters dealing with a classified bibliography which occupies 169 pages.

This work, which forms a standard book of reference, reflects great credit on the author and his assistants and on the publisher.

A Text-book of Orthopedic Surgery. By WILLIS C. CAMPBELL, M.D., F.A.C.S., Professor of Orthopedic Surgery, University of Tennessee College of Medicine, etc. Medium 8vo. Pp. 705, with 504 illustrations. 1930. Philadelphia and London: W. B. Saunders Co. 37s. 6d. net.

IT is somewhat difficult to assess the real object of the author in writing this book. It attempts to cover a very wide range, and consequently varies greatly in the amount of detail in the information provided: on the one hand, many orthopædic conditions

receive a shorter and less complete description than they do in the average text-book of general surgery; on the other hand, certain methods of treatment are dealt with at a length that is of value only to the orthopædic specialist—yet such conditions as congenital club-foot and congenital dislocation of the hip receive only scant attention.

The illustrations are numerous, but a number of them appear to serve little purpose—for instance, in the section on fractures there are many X rays taken before and after treatment, but scarcely any illustrations of methods of treatment. The descriptions of methods of fracture treatment are, themselves, very uneven. Incidentally, a pin $\frac{1}{4}$ in. in diameter is advised for skeletal traction.

The classification of certain conditions of the joints together as low-grade affections seems to serve no useful purpose. They include infectious arthritis, progressive polyarticular and hypertrophic arthritis, gout, syphilis, trophic arthropathies, osteochondritis, endocrine gland disturbances, hæmophilia, neoplasms, and tuberculous arthritis. Similar conditions of the bones appear under the classification of constitutional affections (with the exception of neoplasms), although they are called low-grade affections in the first chapter. This somewhat curious classification goes with a general lack of pathological description that is in evidence throughout the book. It is unlikely that this work will appeal to any group of English readers.

Research and Medical Progress and other Addresses. By J. SHELTON HORSLEY, M.D., Attending Surgeon, St. Elizabeth's Hospital, Richmond, Va. Crown 8vo. Pp. 208. Illustrated. 1929. London: Henry Kimpton. 8s. 6d. net.

THIS is a collection of addresses, mostly of a presidential character, delivered to medical societies and previously published in the medical journals: they are now assembled in book form, the volume being dedicated to the ex-interns of St. Elizabeth's Hospital, Richmond, Virginia. They deal, in the main, with the applications of modern research in physiology and other ancillary sciences to medicine and surgery, with the career and ideals of the modern surgeon, and with the relations of the medical profession to politics and to public authorities. Collectively they constitute a volume of extremely interesting reading, in which the author's opinions on many diverse subjects are concisely and forcibly expressed, and are such as will meet with wide approval. We in this country will appreciate the prominence given to the career of Sir James Mackenzie as illustrative of successful research. On page 41 it is stated that Sir James solved many of his earlier problems "in the isolated Scotch village of Burnley"—an error which must make a quite unintentionally humorous appeal to the 104,000 inhabitants of that typical Lancashire town.

La Rachianesthésie: sa Valeur et sa Place actuelle dans la Pratique. By EMILE FORGUE, Professeur de Clinique chirurgicale à la Faculté de Montpellier; and ANTOINE BASSET, Professeur agrégé à la Faculté de Médecine de Paris; Chirurgien des Hôpitaux. Medium 8vo. Pp. 222, with 23 illustrations. 1930. Paris: Masson et Cie. Fr. 30.

ALTHOUGH both authors have collaborated to produce this monograph, yet since each has written his allotted sections quite independently, some overlapping is only to be expected: they are in mutual agreement, however, in their conclusions. M. Forgue is responsible for the physiology, indications and contra-indications, advantages, and technique of rachianæsthesia, while M. Basset has written of the failures, accidents during and after its administration, their prophylaxis and treatment, and their pathogeny and mortality. Great stress is laid upon the temporary intoxication of the *entire* organism that necessarily accompanies general anæsthesia, more especially its effects upon the functions of the liver and kidneys; and the advisability of minimizing these undesirable effects constitutes a strong argument in favour of local or spinal anæsthesia. A full account is given of the history of spinal anæsthesia,

starting from its accidental discovery by Corning, of New York, in 1885. Its physiology, indications, and technique are thoroughly and judiciously discussed, and the operative details are well illustrated by diagrams and photographs. Preference is given to novocain over the other spinal anæsthetic drugs, but 'percain', so much in evidence just now, is of too recent introduction for discussion in this monograph, nor is anything more than a passing reference made to Pitkin's method of controllable spinal anæsthesia. The uncommon but extremely interesting complication of paralysis of the sixth cranial nerve following upon spinal anæsthesia is described at length, and it is pointed out that eventual recovery is the rule, though one case lasted as long as eight months. An excellent bibliography is appended.

Die Knochenbruchbehandlung mit Drahtzügen. By Prof. Dr. RUDOLF KLAPP, Direktor der chirurgischen Universitätsklinik, Marburg a.d. Lahn.; and Dr. WERNER BLOCK, Chefarzt der chirurgischgynäkologischen Abteilung am Marienhospital, Witten-Ruhr. 10″ × 7″. Pp. 294. Illustrated. 1930. Berlin and Vienna: Urban & Schwarzenberg. Paper covers, RM. 25; bound, RM. 28.

IT is remarkable that a monograph of this size should have been devoted to so small a subject as the treatment of fractures by means of traction on a transfixion wire. Almost half the book is concerned with a description of different varieties of the wire traction apparatus and its method of application. Perhaps one might have been glad to be given a little less in this section, because so many different forms of apparatus are described that the essential simplicity of the method is lost sight of. In its latest and most refined type the method is as follows. The wire is hardened steel 0·75 mm. thick such as is used for pianos. It is inserted by means of Kirschner's apparatus. A given length of wire has one end sharpened and the other is held by a revolving motor. The piece of wire about six inches long is held rigid in a frame which collapses as the wire is driven into place. By this means no separate drill is required. The wire having transfixed the limb, its two ends are held in a special horseshoe-shaped clamp in which it is fixed under light tension. It is claimed that there is so little damage to the tissues that septic infection or sinus can never occur. The great *a priori* objection to this method is that a fine wire to which a traction weight of 25 lb. is attached would tend to travel through the bone. This difficulty is met by saying that in actual practice such a misadventure does not occur, and it is supposed that a reactive inflammation takes place in the bone round the wire track which prevents the wire from pulling through. Experimental specimens are shown, however, in which the wire has actually travelled for some distance. Another definite objection to the wire as compared with the transfixion pin is that the apparatus for its insertion and traction is definitely more complicated.

The remainder of the book is occupied with a systematic description of the application of the wire traction to various fractures. This part might equally well have been written about any efficient method of skeletal traction. We think that the more complicated forms of apparatus in which double transfixion and lateral pulls are combined are not to be recommended for ordinary fracture treatment; but the clear exposition of this newest method of skeletal traction is very valuable for purposes of reference.

The Dramatic in Surgery. By GORDON GORDON-TAYLOR, O.B.E., M.A., F.R.C.S., Surgeon to the Middlesex Hospital. Medium 8vo. Pp. 88. Illustrated. 1930. Bristol: John Wright & Sons Ltd. 12s. 6d. net.

THIS little book represents the substance of an address given by the author to the Manchester Surgical Society. We venture to think that the address has lost and not gained by being committed to cold print, because disconnected accounts of

wonderful cases need the living personality of the narrator to make a dramatic whole. On the other hand, we welcome the book as giving some beautiful coloured illustrations of remarkable specimens which otherwise might have remained unpublished —such are the chrondroma of the ilium, the myeloma of the innominate, and the resected half jaw with an epithelioma. The book, although abounding with personal experiences, is by no means confined to them, and full credit is given to various surgeons who have dared and done great surgical feats.

Radium in General Practice. By A. JAMES LARKIN, B.Sc., M.D., D.N.B., Radium Consultant on Staffs of Wesley Memorial, German Evangelical Deaconess, John B. Murphy, Washington Park Community Hospitals, Chicago, etc. Medium 8vo. Pp. 304 + xiii, with 28 illustrations. 1929. New York: Paul B. Hoeber Inc. $6.00.

THE chief object of this book is to make the general practitioner of medicine conversant with the scope of and indications for the treatment of various general and local diseases by radium. The theoretical and technical aspects of the subject are presented in the barest outline, whereas the clinical aspects are dealt with at some length. It is a very well balanced account of the subject, without making any extravagant claims. The general dangers of and contra-indications to the use of radium are clearly stated at the outset, and special points for caution are repeated under each disease. The principal general diseases discussed are Banti's disease, Hodgkin's disease, hyperthyroidism, and leukæmia. In each of these it is considered that radium is a powerful remedial agent. The other sections are related to various gynæcological conditions, chiefly uterine fibroids and malignant disease; various tumours, simple and malignant; and miscellaneous skin diseases. Short case histories are given illustrative of each condition. These might well have been fuller and more detailed. A considerable list of articles on the subject is added to each chapter. We consider that the author has given a clear, fair, and critical account of the modern use of radium as a therapeutic agent, and that it will be of great value to student, practitioner, and specialist, both for reference and as an introduction to the subject.

L'Ostéo-synthèse métallique dans les Fractures diaphysaires. Etude expérimentale et anatomo-pathologique. Applications pratiques à la Chirurgie humaine By ROBERT FRANTZ, Ancien Interne des Hôpitaux de Paris. With a Preface by Professeur BERNARD CUNÉO. Royal 8vo. Pp. 190. Illustrated. 1929. Paris: Masson et Cie. Fr. 35.

THIS is a record of experiments on dogs to ascertain the effect of various metallic contrivances used in the operative treatment of fractures. They are concerned mainly with the form of the apparatus rather than with the nature of the metal. Eleven dogs were operated upon; in four the bone was not fractured, but a screw, a Lambotte plate and screws, Cunéo's staple and wire, and a Hallopeau plate fixed by Parham's bands were used respectively. The histological results are described in considerable detail and show that the compact bone in the region of the metal undergoes rarefaction, and that if the medulla is reached a marked fibrous reaction occurs round the metal.

In the other seven dogs the bone was broken and then fixed in various ways. Three of these cases did not heal satisfactorily, so that only four dogs with six fractures were available for study, there being two fractures treated with Cunéo's staple and wire, Hallopeau's plate with Parham's bands, and Contremoulin's perforated aluminium-bronze sleeve respectively.

The deductions drawn are that the fragments should be securely fixed and that the apparatus should spread its force over a considerable area of bone so that the pressure should not be too great at any one point, and that for this purpose the Contremoulin sleeve is best adapted.

The first point has already been decided by much experience in the treatment of fractures in man, and the evidence in these experiments is insufficient to show that any one of the methods here used is the best. With regard to the second point, the Contremoulin sleeve undoubtedly secures a wide area of application, and does not, unless too tightly applied, damage the underlying bone and medulla, but it does limit the formation of the external callus opposite the fracture.

L'Arthrite chronique de la Hanche. By L. DUVERNAY, Médicin consultant à Aix-les-Bains. Medium 8vo. Pp. 145, with 51 illustrations. 1930. Paris: Masson et Cie. Fr. 40.

THIS monograph is a concise and readable account of chronic arthritis of the hip-joint based on the considerable experience of the writer as a physician at Aix. Although it contains little original matter, there is much that will interest the orthopædic surgeon. The writer divides chronic arthritis of the hip into two main groups: (1) Where arthritis develops in a hip previously normal; (2) Where the arthritis is superimposed in a hip-joint deformed since childhood as a result of congenital subluxation, coxa plana, or coxa vara. In the clinical picture the author stresses four early signs: (1) Limitation of abduction and adduction; (2) The 'shoe' sign—that is, inability of the patient to take off his shoe in the ordinary way; (3) Pain referred to the inguinal region; and (4) Relatively free range of flexion until the later stages. The surgical treatment is briefly discussed. The author's preference is for arthrodesis, if the patient is fit to undergo the fairly severe ordeal which this operation entails. The advantages of reconstructive excision of the femoral head do not appear to be familiar to the author.

Die Wirbelbrüche und ihre Endergebnisse. By Dr. WALTER HAUMANN, Medical Superintendent of the Evangelical Hospital, Hattingen in Ruhr. Super royal 8vo. Pp. 180, with 20 illustrations. 1930. Stuttgart: Ferdinand Enke. Paper covers, RM. 19; bound, RM. 21.

THIS monograph is one of considerable value because it gives a critical and analytical account of over two hundred consecutive cases of fracture of the vertebræ. The distribution of the lesions was: cervical 10, dorsal 56, lumbar 138. The spinal cord was affected in 100 per cent of the cervical fractures and in only 50 per cent of those of the dorsal and lumbar regions; 71 per cent were caused by indirect violence, and 29 per cent by direct. The vertebra most often injured was the 1st lumbar, then the 2nd lumbar, and then the 12th dorsal. Certain generalizations are made. Cord lesions are held to be a contra-indication for operation, and the value of a stabilizing bone-graft or ankylosing operation for cases without nerve lesion is hardly recognized. No case of late development of symptoms (Kümmel's disease) was observed, neither was there a single case in which tuberculous disease followed injury. Local spondylitis deformans, however, was comparatively common. Special attention is given to cases of exceptional interest—for example, one case of unilateral cord lesion with Brown-Séquard syndrome, and one of double brachial plexus lesion, both these being in fractures of the cervical region.

Diabetic Surgery. By LELAND S. MCMITTRICK, M.D., F.A.C.S., Visiting Surgeon, Palmer Memorial Hospital; and HOWARD F. ROOT, M.D., Assistant Physician, New England Deaconess Hospital. 9½″ × 6″. Pp. 269 + ix, with 79 illustrations in the text and 2 plates. 1929. London: Baillière, Tindall & Cox. 21s. net.

THE worst thing about this book is its title, and we trust that the authors will see their way to altering it to "Surgery of Diabetes" in the next edition—for the book is of great value and we feel sure that another edition will soon be needed. The

main object of the work is to correlate the treatment of diabetes by diet and insulin with that of surgical operation. Before the discovery of insulin it was rightly held that many cases of diabetes requiring surgical treatment presented so grave a risk that coma and death would probably supervene. Now insulin therapy has changed all this, and there is hardly ever a case in which the advantages of surgery need be denied to the diabetic. The tabulation of suitable diets and the dosage of insulin in relation to such diet is, we think, the most valuable feature of the book.

The largest section is devoted to a discussion of gangrene and the allied lesions of the lower extremities. This includes a careful discussion of the distinction between arteriosclerotic and septic types of gangrene and the determination of the proper site of amputation in each case. We think that some reference ought to be made to the nerve lesions, e.g., neuritis, and to arterial spasm, with the allied question of the rôle of sympathectomy.

The other chapters deal with gangrene of the upper extremities including whitlows, carbuncles, abdominal surgery, thyroid diseases, and malignant disease. The book concludes with a useful list of technical methods.

Die Chirurgie. A System of Surgery. Edited by Profs. M. KIRSCHNER (Tübingen) and O. NORDMANN (Berlin). Royal 8vo. Berlin and Vienna: Urban & Schwarzenberg.

FASCICULUS 26 (Vol. II). Pp. 1583–1828, with 175 illustrations in the text and one coloured chart. 1930. RM. 18.

THIS section, which deals with the surgery of the bones, is by Dr. Leopold Schonbauer, of Vienna. In regard to the completeness of its subject-matter, the wealth of original illustrations, and the extensive references to literature, it is excellent, and forms a most valuable work of reference.

The section begins with a short but clear summary of our knowledge of the anatomy and physiology of bones, discussing the various conditions which influence growth and development. Then follows a short account with good illustrative figures of the chief congenital malformations, especially the so-called congenital amputation. Various theories about the rôle of the periosteum and the causal agents in bone regeneration are stated, but we are surprised that the work of Macewen is not referred to. The section on osteomyelitis is rather disappointing owing to its brevity. The vexed question as to whether incision of the periosteum is sufficient treatment of the acute disease or whether the medulla should always be opened is not definitely answered, but the balance of the arguments given is in favour of the former procedure.

The sections on osteitis fibrosa, osteitis deformans, and the new growth of bone are notable for the wealth of good illustrations. From a practical point of view it would perhaps have been of greater value if more of the early stages and less of the late stages of these diseases had been described. The section on fractures and their treatment is too brief to be of much practical value. Operative treatment and bone-grafting are hardly mentioned.

The chief value of this book to English readers is found in the good illustrations of rare and unusual diseases and the extensive lists of references to Continental authorities.

FASCICULUS 27 (Vol. III). Pp. 609–832, with 171 illustrations. 1930. RM. 14.

THE present section by Dr. E. Heymann, of Berlin, is confined to a consideration of the diseases of the spinal cord and its membranes. The introductory chapter contains a generous appreciation of the part taken in the foundation of the surgery of the spinal cord by Macewen and Horsley. The account of the anatomy and physiology of the cord is very clear and complete, and is enriched by many valuable diagrams showing the segmental distribution of the nerves. One of these of the

innervation of the viscera would make the monograph worth having, even if it contained nothing else. There are also full and well illustrated accounts of the tumours of the cord, of the operation of chordotomy, and the various ways of exposing the spinal cord. This and the section on the peripheral nerves are among the best monographs in this work.

FASCICULUS 28 (Vol. III). Pp. 833-980, with 71 illustrations in the text, many in colour, and 2 coloured plates. 1930. RM. 11.

THIS section by Professor Lebemann (Frankfort-on-Main) is devoted entirely to the surgery of the peripheral nerves. It begins with general considerations relating to the anatomy of normal nerves and the results of their division. Interesting statistics are given of the frequency of injury to individual nerves. Thus the first four nerves in order of frequency in regard to injury are the ulnar (158), the musculospiral (129), the median (117), and the sciatic (55). The importance of early operation is shown by a table in which the percentage of successes after suture was 100 in cases done within two months of injury, 62 within six months, and 25 within twelve months. It is considered that suture is worth while up to two years after the division.

In describing various operative procedures for making good defects in the nerve it is probable that undue prominence is given to ingenious devices which have little or no practical value, but these methods are well described and illustrated.

The section devoted to the special nerves is good and helpful—for example, the figures of the exposure of the sensory root of the trigeminal nerve are very clear, and the muscle substitution operations for facial paralysis are equally well given, as are those for dealing with a cervical rib. The subject of the peripheral nerves does lend itself to treatment in a small and compact monograph such as this, and we think that the author has done justice to the subject. Also he has been much more catholic in his appreciation of workers outside Germany than many other contributors to this great system of surgery which is now nearing completion.

Handbook on Tuberculosis. By B. S. KANGA, M.D., D.P.H., Medical Officer, Turner Dispensary, and Visiting Medical Officer, Turner Sanatorium (Bombay Municipality). Crown 8vo. Pp. 150 + viii. Illustrated. 1930. London: John Bale Sons & Danielsson. 5s. net.

THIS handbook is a short and clearly written account of tuberculosis of such an elementary character as to make it suitable for propaganda purposes amongst non-medical readers. It contains a strong plea for proper organization of prophylactic measures for the prevention of the disease and of a system of sanatoria and dispensaries for its treatment. Questions of surgical treatment are only mentioned very briefly.

Die Wiederbelebung: Eine zusammen-fassende Darstellung ihrer Theorie und Praxis. By Prof. Dr. OSKAR BURNS and Dr. KARL THIEL, der Medizinischen Universitäts-Poliklinik, Königsberg. Super royal 8vo. Pp. 109, with 26 illustrations. 1930. Berlin and Vienna: Urban & Schwarzenberg. RM. 9.

THE authors consider that, owing to the rapid advance of industrial machinery and electricity as well as to the increased number of motor accidents, there is a marked increase in the number of cases of loss of consciousness with temporary cessation of respiration and circulation in which restorative methods may be necessary. Within the compass of a very short and practical monograph is given a complete account of the whole subject of the signs of death and the methods of restoration of life, together with a sufficient reference to theoretical considerations and scientific experiment to enable the reader to get a practical knowledge of the subject or to pursue any special branch of it in further detail.

After a general section concerned with the restoration of circulation and respiration, a special section follows dealing with special types of death, e.g., that by freezing, by heat stroke, by electrical currents, poisoning by carbon monoxide, benzine, alcohol, morphia, and various anæsthetics and narcotics. The book concludes with a list of references to literature dealing with these subjects.

The Clinical Pathology of Thoracic Puncture Fluids. By S. ROODHOUSE GLOYNE, M.D., D.P.H., Pathologist, City of London Hospital for Diseases of the Heart and Lungs, Victoria Park. Post 8vo. Pp. 83 + vii. Illustrated. 1930. London: John Bale Sons & Danielsson. 10s. 6d. net.

THIS small book is a practical attempt to aid diagnosis in early and obscure diseases of the chest by means of examination of the fluids withdrawn from the pleural cavity by an exploring syringe. Chief reliance is placed upon the number and character of the cells, but bacteriological examination and fixation tests also are used. It is considered that the great majority of acute serous pleural effusions are of tuberculous nature. In the case of empyema, the nature and number of the organisms found is a valuable guide not only to treatment but also to prognosis.

BOOK NOTICES.

[*The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.*]

Shorter Convalescence. By Lieut.-Colonel JAMES K. MCCONNEL, D.S.O., M.C., Member of the Chartered Society of Massage and Medical Gymnastics; Bio-physical Assistant (working at St. Thomas's Hospital). With a Foreword by Sir ROBERT JONES, Bart., K.B.E., C.B., F.R.C.S. Crown 8vo. Pp. 132 + xi. Illustrated. 1930. London: William Heinemann (Medical Books) Ltd. 5s. net.

Collected Papers of the Mayo Clinic and the Mayo Foundation. Edited by Mrs. M. H. MELLISH, RICHARD M. HEWITT, M.A., M.D., and MILDRED A. FELKER, B.S., Vol. XXI. 1929. Medium 8vo. Pp. 1197 + xxiii, with 276 illustrations. 1930. Philadelphia and London: W. B. Saunders Co. 60s. net.

Surgical Diagnosis. By American authors. Edited by EWARTS AMBROSE GRAHAM, A.B., M.D., Bixby Professor of Surgery, School of Medicine, Washington University, St. Louis, etc. Volume III. $9\frac{1}{2}'' \times 6''$. Pp. 1043, with 446 illustrations. 1930. Philadelphia and London: W. B. Saunders Co. Per set—three volumes and index volume, £7 10s.

Physiologie, pathologique chirurgicale. Inflammations, Effects des Traumatismes, Reparation des Plaies, Greffes, Maladies des Os, des Articulations, des Vaisseaux et des Nerfs. By R. LERICHE, Professeur de Clinique chirurgicale à la Faculté de Strasbourg; and A. SOLICARD, Professeur d'Histologie à la Faculté de Lyon. Medium 8vo. Pp. 212. 1930. Paris: Masson et Cie. Fr. 26.

Plarr's Lives of the Fellows of the Royal College of Surgeons of England. Revised by Sir D'ARCY POWER, K.B.E. (Mil.), F.R.C.S., Hon. Librarian Royal College of Surgeons; with the assistance of W. G. SPENCER, O.B.E., M.S., F.R.C.S., and Professor G. E. GASK, C.M.G., D.S.O., F.R.C.S. In two volumes. Royal 8vo. Vol. I: Pp. 752 + xxvi. Vol. II: Pp. 596. 1930: Printed and published for the Royal College of Surgeons by John Wright & Sons Ltd., Bristol. Cloth, 42s. net; half bound, 57s. 6d. net.

La Sacro-Coxalgie et son Traitement. By PIERRE INGELRANS, Chef de Clinique de Chirurgie Infantile à la Faculté de Médecine de Lille. Preface by RENÉ LE FORT. $9\frac{1}{2}'' \times 6\frac{1}{4}''$. Pp. 140, with 6 plates. 1930. Paris: Masson et Cie. Fr. 30.

La Pratique chirurgicale illustrée. By VICTOR PAUCHET. Fasc. XVI. Super royal 8vo. Pp. 220, with 175 illustrations drawn from nature by S. Dupret. 1930. Paris: G. Doin et Cie. Fr. 65.

On Faith and Science in Surgery. By Sir JOHN BLAND-SUTTON, Bart., Vice-president and Consulting Surgeon to the Middlesex Hospital. Post 8vo. Pp. 109 + xii. Illustrated. 1930. London: William Heinemann (Medical Books) Ltd. 7s. 6d. net.

Gonococcal Infection in the Male. By ABR. L. WOLBARST, M.D., Urologist and Director of Urologic Clinics, Beth Israel Hospital, etc. Second edition, completely revised and enlarged. Medium 8vo. Pp. 297, with 140 illustrations, including 7 colour plates. 1930. London: Henry Kimpton. 25s. net.

Ueber die schmerzhafte Schulterversteifung (Periarthritis humeroscapularis). By Prof. Dr. E. SEIFERT, Oberarzt der chirurgischen Univ.-Klinik, Würzburg. $9\frac{1}{2}'' \times 6\frac{3}{4}''$. Pp. 283–317, with 13 illustrations. 1930. Leipzig: Curt Kabitsch. RM. 4.

Guy's Hospital Reports. Edited by ARTHUR F. HURST, M.D. Vol. LXXX (Vol. X Fourth Series), No. 3. July, 1930. Royal 8vo. Pp. 253–378. Illustrated. 1930. London: The Lancet Ltd. Single numbers, 12s. 6d. net; annual subscription, £2 2s. net.

Die spezielle Chirurgie der Gehirnkrankheiten. Three volumes. Vol. I, compiled by Dr. K. BOSHAMER, Prof. GUSTAV BRUHL, Prof. N. GULEKE, Dr. E. HARMS, Dr. G. JORNS, Prof. HANS SMIDT, Prof. C. TH. WILLICH. Edited by Prof. FEDOR KRAUSE. Royal 8vo. Pp. 735 + xxiv, with 41 illustrations. 1930. Stuttgart: Ferdinand Enke. Paper covers, RM. 96; bound, RM. 99.

The Metabolism of Tumours. Investigations from the Kaiser-Wilhelm Institute for Biology, Berlin-Dahlem. Edited by OTTO WARBURG, Kaiser-Wilhelm Institute for Biology, Berlin-Dahlem. Translated from the German edition with accounts of additional recent researches, by FRANK DICKENS, M.A., Ph.D., whole-time worker for the Medical Research Council, Courtauld Institute of Biochemistry, Middlesex Hospital, London. Demy 8vo. Pp. 327 + xxiv. Illustrated. 1930. London: Constable & Co. Ltd. 40s. net.

Lehrbuch der Mund- und Kieferchirurgie. By Prof. Dr. ERICH SONNTAG, A.O. Planmässiger Prof. der Chirurgie und Direktor des Chirurgisch-Poliklinisch Instituts der Universität Leipzig; and Prof. Dr. WOLFGANG ROSENTHAL, A.O. Prof. der Chirurgie an der Universität Leipzig. Royal 8vo. Pp. 444 + xv, with 501 illustrations. 1930. Leipzig: Georg Thieme. Paper covers, M. 24; bound, M. 26.

Surgical Pathology and Morbid Anatomy (Bowlby and Andrews). Revised by GEOFFREY KEYNES, M.A., M.D., F.R.C.S., Assistant Surgeon, St. Bartholomew's Hospital. Eighth edition. Medium 8vo. Pp. 644 + x, with 224 illustrations. 1930. London: J. & A. Churchill. 21s. net.

Minor Surgery and Bandaging For the Use of House Surgeons, Dressers and Junior Practitioners. By GWYNNE WILLIAMS, M.S., F.R.C.S., Surgeon, University College Hospital. Twentieth edition. Crown 8vo. Pp. 445 + viii, with 2621 illustrations. 1930. London: J. & A. Churchill. 10s. 6d. net.

The Science and Practice of Surgery. By W. H. C. ROMANIS, M.A., M.B., M.Ch. Cantab., F.R.C.S., F.R.S. (Edin.), Senior Surgeon in Charge of Out-patients, Surgeon to the Isolation Block, and Teacher of Practical Surgery, St. Thomas's Hospital, etc., and PHILIP H. MITCHINER, M.D., M.S. (Lond.), F.R.C.S., Surgeon in charge of Out-patients, Teacher of Operative Surgery, and Demonstrator of Anatomy, St. Thomas's Hospital, etc. Third edition. In two volumes, with 716 illustrations. Vol. I, General Surgery. Pp. 772 + x. Vol. II, Regional Surgery. Pp. 950 + x. 1930. London: J. & A. Churchill. 14s. each volume.

Manual of Surgery for Students and Practitioners (Rose and Carless). By CECIL P. G. WAKELEY, F.R.C.S., F.R.S. Edin., Erasmus Wilson Lecturer, Royal College of Surgeons of England; Surgeon, King's College Hospital, etc.; and John B. HUNTER, M.C., M.Chir., Cantab., F.R.C.S., Assistant Surgeon, King's College Hospital, etc., Thirteenth edition. $9\frac{1}{2}'' \times 6\frac{1}{2}''$. Pp. 1592 + xii, with 664 illustrations in the text, 19 coloured, and X-ray supplement. 1930. London: Baillière, Tindall & Cox. 30s. net.

Die Chirurgie. Edited by Profs. M. KIRSCHNER (Tübingen), and O. NORDMANN (Berlin). Fasc 29 (Vol. II). Royal 8vo. Pp. 1829–2028, with 98 illustrations. 1930. Berlin and Vienna: Urban & Schwarzenberg. RM. 16.

Die Mund- und Halsoperationen. By Prof. Dr. J. SOERENSEN (Berlin). Super royal 8vo. Pp. 457 + x, with 42 black-and-white illustrations and 48 coloured plates. 1930. Berlin and Vienna: Urban & Schwarzenberg. Paper covers, RM. 85; bound, RM. 95.

The Student's Handbook of Surgical Operations. By Sir FREDERICK TREVES, Bart., G.C.V.O., C.B., LL.D., F.R.C.S., revised by CECIL P. G. WAKELEY, F.R.C.S.Eng., F.R.S.Edin., Surgeon to King's College Hospital, etc. Fifth edition. Crown 8vo. Pp. 535 + xi, with 190 illustrations. 1930. London: Cassell & Co. Ltd. 10s. 6d. net.

Cancer of the Lung and other Intrathoracic Tumours. By MAURICE DAVIDSON, M.A., M.D., B.Ch. (Oxon.), F.R.C.P. (Lond.), Physician to the Brompton Hospital for Diseases of the Chest, etc. With a Foreword by ARTHUR J. HALL, M.A., M.D., D.Sc., F.R.C.P. (Lond.), Professor of Medicine, University of Sheffield. Super royal 8vo. Pp. 173 + x, with 62 illustrations. 1930. Bristol: John Wright & Sons Ltd. 17s. 6d. net.